

The Lake Sturgeon, *Acipenser fulvescens* (Chondrostei: Acipenseridae): An Annotated Bibliography

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THE LAKE STURGEON, *Acipenser fulvescens*
(CHONDROSTEI: ACIPENSERIDAE):
AN ANNOTATED BIBLIOGRAPHY

by

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ABSTRACT

Dick, T.A., Jarvis, S.R., Sawatzky, C.D., and Stewart, D.B. 2006. The lake sturgeon *Acipenser fulvescens* (Chondrostei: Acipenseridae): an annotated bibliography. Can. Tech. Rep. Fish. Aquat. Sci. 2671: iv + 251 p. + CD-ROM.

This bibliography cites and annotates 1,317 literature references on lake sturgeon covering the period 1817 to 2005. It is supported by an electronic bibliographic database in ProCite software that can be searched and sorted. Many of the studies are on the population biology, natural history, management, and conservation of lake sturgeon, which is currently under consideration for listing in Canada under the *Species at Risk Act* (SARA). This information base is designed to facilitate efforts by regulators, stakeholders and the public to manage, conserve or recover existing populations of this important species.

Key words: lake sturgeon; *Acipenser fulvescens*; bibliographies; biology; life history; ecology; reproduction; parasitism; fish culture; harvesting; renewable resource use; fish physiology; stock status; geographic distribution.

RÉSUMÉ

Dick, T. A., Jarvis, S.R., Sawatzky, C.D., and Stewart, D.B. 2006. The lake sturgeon *Acipenser fulvescens* (Chondrostei: Acipenseridae): an annotated bibliography. Can. Tech. Rep. Fish. Aquat. Sci. 2671: iv + 251 p. + CD-ROM.

Cette bibliographie cite et annote 1317 références documentaires sur l'esturgeon jaune pour la période de 1817 à 2005. Elle est appuyée par une banque de données bibliographique et électronique utilisant le logiciel ProCite qui permet les recherches électroniques. Un grand nombre des études portent sur la biologie de la population, l'histoire naturelle, la gestion, et la conservation de l'esturgeon jaune, qui est actuellement en considération pour être inscrit au Canada en vertu de la *Loi sur les espèces en péril* (LEP). Cette base d'information est conçue afin de faciliter les efforts des organismes de réglementation, des intervenants, et du public pour gérer, conserver ou récupérer les populations existantes de cette espèce importante.

Mots clés: esturgeon jaune; *Acipenser fulvescens*; bibliographies; biologie; histoire de vie; écologie; reproduction; parasitisme; pisciculture; récolte; utilisation des ressources renouvelables; physiologie du poisson; état des stocks; répartition géographique.

INTRODUCTION

This annotated bibliography, and its accompanying database, update sources of our current knowledge of the lake sturgeon (*Acipenser fulvescens*) of North America, adding significantly to a previous compilation by Dick and Choudhury (1992). Interest in the conservation of this species in both Canada and the United States, coupled with advances in science and research have added significantly to the knowledge of the species' ecology, culture, and molecular biology. This improved information base, and ready access to it, enhances the ability of regulators, stakeholders and the public to effectively manage, conserve or recover existing populations of this important species. In Canada, the lake sturgeon is currently under consideration for listing under the *Species at Risk Act* (SARA) adding to the timeliness of this publication.

The lake sturgeon is the largest freshwater fish species in Canada. Historically, it was widely distributed across North America (Figure 1) and played a significant role in the culture and livelihood of many First Nations peoples. Commercial harvesting of sturgeon began after 1860 and expanded rapidly across the continent. In general, initial heavy exploitation led to the collapse of individual fisheries as stocks became rapidly depleted. Fishing effort was then redirected to unexploited populations in other areas, where the cycle was allowed to repeat itself. In this fashion, lake sturgeon populations were progressively depleted over most of their historical range by the early 20th century. Severe declines in both the distribution and abundance of lake sturgeon in Canada have been documented over the years with limited success in the recovery of exploited populations. In many cases, recovery of the species is severely hampered by factors such as the slow growth and late maturity coupled with continuing exploitation and habitat impairment.

If the lake sturgeon is listed under SARA, considerable efforts and resources will be required to maintain current populations, and to implement appropriate recovery strategies. The

growing knowledge base captured in this publication will hopefully move us further in the direction of recovering this magnificent fish species.

The purpose of this bibliography and database is to make it easier to locate, sort, and format reference materials needed to manage the lake sturgeon and promote its recovery. These include 1,317 citations for published and unpublished scientific and popular reference materials that pertain to the lake sturgeon. Many of the studies are on the population biology, natural history, management and conservation of lake sturgeon, although some deal with the historical, social, economic and legal aspects of its use. Excerpts from general references (e.g., books) have not been referenced unless they provide new information. The content of each reference is described in a short annotation that highlights its contribution to knowledge of the species. Citations have been included for abstracts, but only those identified early in the process have been annotated.

The references are presented in two sections, the Bibliography, which includes primary publications and unpublished reports, and Additional Materials, which includes citations for websites and newspaper articles. Where information on a particular topic is lacking, useful studies from other sturgeon species have been included. Citations in the bibliography are organized alphabetically by author. The bibliography itself has not been indexed, but the reference material can be searched and sorted using some of the special functions in the electronic database.

Citations included in the bibliography and database were identified from:

- an earlier bibliography prepared by Dick and Choudhury (1992);
- personal bibliographies and libraries of literature on the species held by the authors and by scientists at the Freshwater Institute (Fisheries & Oceans Canada), Ontario Ministry of Natural Resources (OMNR), North/South Consultants Inc.

(Winnipeg, MB), Québec Hydro, and U.S. Fish and Wildlife Service;

- citations in the literature, library searches and contacts with people knowledgeable of the species;
- computer searches of abstracts and bibliographic databases, including:
 - Aquatic Sciences and Fisheries Abstracts (ASFA) (<http://www.csa.com/factsheets/aquicust-set-c.php>), Environmental Science and Pollution Management Abstracts, WAVES (<http://inter01.dfo-mpo.gc.ca/waves2/index.html>), Ingenta (<http://www.ingentaconnect.com>), and Scopus (<http://www.scopus.com>) with records up to and including 2005 and in WAVES, the Fisheries and Oceans Canada libraries' catalogue;
 - Biological Abstracts and Zoological Record databases with records up to and including 2004 provided by the University of Manitoba Libraries Networked Databases on Campus service (NetDoc);
 - EBSCOhost, JStor, ProQuest Research Library, Science Direct, and Web of Science, provided through the University of Winnipeg Library database collection, and Cambridge Life Sciences Abstracts for 1986-2004, Aquatic Sciences and Fisheries Abstracts 1988-2004, and Science Citation Compact Disc 1987-1991; and,
- searches of the internet using Google (<http://www.google.com>).

The ProCite database, which is provided on a CD inside the back cover of this report, includes all of the same references found in the printed report. Copies of most of these references have been archived at the Eric Marshall Aquatic Research Library (Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, MB, R3T 2N6). The database was prepared using ProCite (Ver. 5) software, but can also be opened using Reference Manager software. It is

searchable by computer using key words, and will be updated as new material is located. The organization and use of the database is detailed in the "Readme" file on the CD. The database is not for commercial sale or distribution.

Like any work of its type, this bibliography and database may have gaps in coverage and errors. Searches of other computerized bibliographic databases, for example, located relatively few pre-1960 references, and missed a number of key references. We have attempted to fill these gaps which stem from the relatively recent development of computerized bibliographic databases, as well as from monetary constraints on the input of such data. Where a reference was not reviewed the source of the citation is provided wherever possible, to direct users to the original bibliographic source. We have worked to ensure that the citations are correct, and apologize for any errors. Please direct any comments regarding errors or omissions to D.B. Stewart at stewart4@mts.net.

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Many people contributed reference citations and or materials from their collections, particularly Anindo Choudhury who co-authored the 1992 sturgeon bibliography, which this work built upon; Frank Bishop, Terry Clayton, and Daryl Watters of the Government of Alberta; Rob Wallace of the Government of Saskatchewan; Martin Erickson, Ken Kansas, Doug Leroux, Walt Lysack, Don Macdonald, and Barb Scaife of the Government of Manitoba; Tim Haxton, Charles Hendry, Lloyd Mohr, and Tom Mosindy of the Government of Ontario; Pierre Dumont of the Government of Québec; Bill Franzin, Mike Papst, Jim Reist, and Sam Stephenson of Fisheries and Oceans Canada; Luther Aadland of the Minnesota Department of Natural Resources; Ron Bruch of the Wisconsin Department of Natural Resources; Henry Quinlan of the U.S. Fish and Wildlife Service in Ashland, Wisconsin; Chief Willi Wilson of Manitou Rapids (Rainy River Band); Marcy Bast of SaskPower; Shelley Matkowski of Manitoba Hydro; Richard Verdon of Québec Hydro; Steve Peake of the University

of New Brunswick; Nancy Auer of Michigan Technological University; and Don MacDonell and Richard Remnant of North/South Consultants Inc. in Winnipeg.

Elva Simundsson, Marge Dyck, and Jane Martin of the Eric Marshall Aquatic Research Library at the Freshwater Institute in Winnipeg, Manitoba (Fisheries and Oceans Canada) and staff of the Interlibrary Loans Unit and Reference Branch of the Science Library at the University of Manitoba helped us to identify and obtain many of the references cited in this bibliography. Dr. E. Raikova of the Institute of Cytology in St. Petersburg, Russia translated some of the French publications; Colin Gallagher of the University of Manitoba translated others. Papers and reports collected during the compilation of this bibliography have been deposited with the Eric Marshall Aquatic Research Library (Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, Manitoba R3T 2N6).

Elva Simundson reviewed the manuscript, Fred Hnytka reviewed the introductory text and the accompanying ProCite database, and Marge Dyck reviewed the ProCite database.

Fred Hnytka of Fisheries and Oceans Canada was the Scientific Authority for this project and provided welcome resources, advice, and information.

All of the contributions from these individuals have greatly improved this work and we thank them.

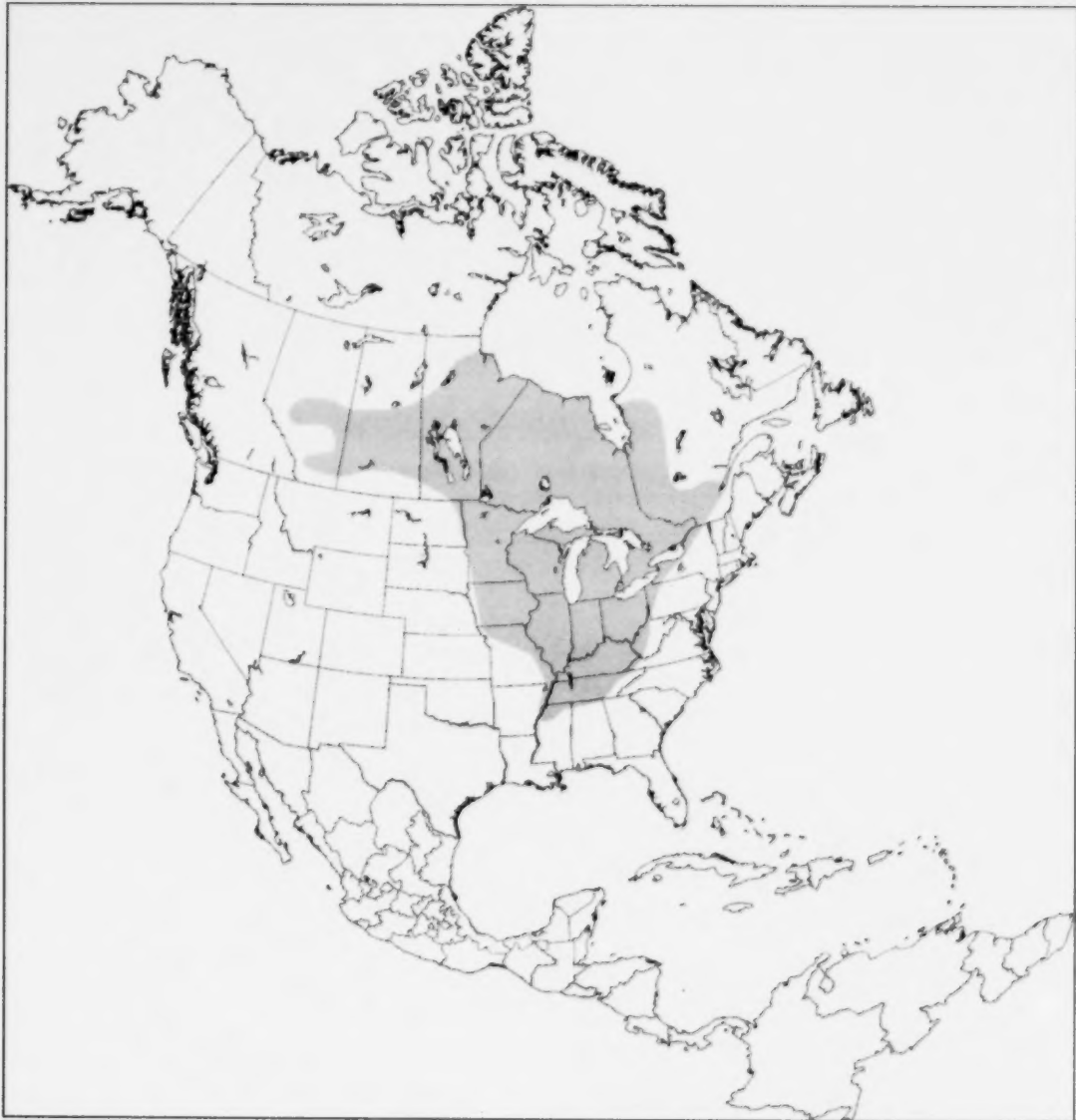


Figure 1. Historical distribution of lake sturgeon (*Acipenser fulvescens*) in North America (from Earle 2002).

BIBLIOGRAPHY

Aadlund, A. 2005. Passage and habitat restoration for lake sturgeon. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 84 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 31 March 2006].

Adams, S.R., Hoover, J.J., and Killgore, K.J. 1999. Swimming endurance of juvenile pallid sturgeon, *Scaphirhynchus albus*. *Copeia* 1999: 802-807.

The swimming endurance of juvenile pallid sturgeon was reported as being similar to lake sturgeon of equal size, but less than that of other sturgeon species.

Adams, W., Jr., Kallemeyn, L., and Willis, D. 2004. Seasonal distribution of lake sturgeon in Rainy Lake. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Forty-one adult lake sturgeon from the southern arm of Rainy Lake were implanted with combined acoustic/radio transmitters in 2002 and 2003 to determine spawning locations and habitat use. The majority of the lake sturgeon locations were associated with rocky structures and water less than 30 m deep. They typically used shallow water habitats during June, July, and August and were found below dams in two Rainy Lake inflows during the spawning seasons. Spawning locations were consistent with historically known spawning areas.

Adamstone, F.B. 1923. The distribution and economic importance of Mollusca in Lake Nipigon. Univ. Toronto Stud. Biol. Ser. 22, Publ. Ont. Fish. Res. Lab. 14: 69-118.

A section of this paper dealt with the value of molluscs as fish food. An examination of sturgeon digestive tracts showed "conclusively" that the sturgeon subsisted to a large extent on molluscs, ingesting almost all the smaller gastropods and bivalves. Sixteen species of molluscs were listed from lake sturgeon

stomachs represented by the genera *Lymnaea* (four spp.), *Valvata* (two spp.), *Amnicola* (two spp.), *Planorbis* (three spp.) and *Physa* (two spp.) as well as three species of Sphaeriidae. It was hypothesized that molluscs constituted 100% of the diet.

Adamstone, F.B. 1924. The distribution and economic importance of the bottom fauna of Lake Nipigon. Publ. Ont. Fish. Res. Lab. 24: 33-100 (Univ. Toronto Stud. Biol. Ser. 25).

The study by Harkness on the food of lake sturgeon in Lake Nipigon was discussed. The main prey taken by sturgeon included chironomids, molluscs and ephemeroptera. Crayfish were also an important part of the lake sturgeon diet in certain areas.

Agassiz, L. 1850. Lake Superior. Its physical character, vegetation and animals, compared with those of other similar regions. Gould, Kendall and Lincoln, Boston, Massachusetts. 428 p.

In this book, the author described three new species of sturgeon, all from Lake Superior: *Acipenser laevis* (p. 267); *A. carbonarius* (p. 271) and *A. rhynchaeus* (p. 276). All three species were subsequently synonymized with the lake sturgeon, *Acipenser rubicundus*, by Kirsch and Fordice (1889) (see in this bibliography).

Alberta Environmental Protection, Natural Resources Service, and Alberta Conservation Association. 1998. Alberta's fish. A series of informative brochures about Alberta's fish species. Lake sturgeon, *Acipenser fulvescens*. Alberta Environmental Protection, Natural Resources Service. 6 p. [Brochure].

A general description of lake sturgeon and discussion of its distribution in North America was given. In Alberta, the lake sturgeon is only found in the North and South Saskatchewan river systems. Historical and current status, size and maturity, habitat and food, and management outlook were also discussed.

Aloisi, D. 1997. Lake sturgeon fingerling culture using heated recirculated water, p. 458. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only]

Amaral, S. 2001. Evaluation of angled bar racks and louvers for guiding juvenile lake sturgeon (age 1). United States Fish and Wildlife Service, Green Bay Ecological Services Field Office, New Franken, WI. 18 p.

This document was not available for annotating.

Amaral, S., and Sullivan, T. 2005. Downstream fish passage for sturgeon. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 41 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 31 March 2006].

Amaral, S.V., Black, J.L., McMahon, B.J., and Dixon, D.A. 2002. Evaluation of angled bar racks and louvers for guiding lake and shortnose sturgeon, p. 197-210. *In* W. Van Winkle, P. J. Anders, D. H. Secor, and D. A. Dixon. (ed.) Biology, management, and protection of North American sturgeon. American Fisheries Society, Symposium 28, Bethesda, Maryland.

The effectiveness of various configurations of angled bar racks and louvers for sturgeon passage over a range of velocities, and the swimming abilities of sturgeon were examined. Young-of-the-year (YOY) lake sturgeon were tested with the guidance structures angled at 45 and 15 degrees to the approach flow, and with a perpendicular bar rack with no guidance structure. Age-1 lake and shortnose sturgeon were tested with the guidance structures angled at 15 degrees only. Guidance efficiency was estimated at three approach velocities, 0.3, 0.6, and 0.9 m/s, by noting the percentage of fish that were diverted to a full-depth bypass. The YOY lake sturgeon showed low guidance efficiency (<37%) for all of the test configurations. An approach velocity of 0.3 m/s resulted in the highest guidance efficiencies for YOY lake sturgeon, and 0.9 m/s resulted in the lowest guidance efficiencies. In tests with the perpendicular bar rack but no guidance structure, the guidance efficiency was 0%. Age-1 lake and shortnose sturgeon showed high guidance efficiencies (>90%) at all velocities. The authors conclude the differences between YOY and age-1 lake sturgeon may be due to swimming capabilities. They recommend not using angled bar racks and louvers for sturgeon less than 200 mm in length.

Amaral, S.V., Winchell, F.C., McMahon, B.J., and Dixon, D.A. 2000. Evaluation of an angled bar rack and a louver array for guiding lake sturgeon to a bypass. *In* 130th AFS Annual Meeting, St. Louis, MO. 20-24 August, 2000. Reflections. Pagination unknown. [Abstract only]. Available from http://www.ecu.edu/org/afs/St_Louis/abssturgeon/r956602017-00.htm [accessed 30 March 2006].

Amemiya, C.T., and Litman, G.W. 1991. Early evolution of immunoglobulin genes. *Amer. Zool.* 31: 558-569.

This paper reviewed the immunoglobulin genes from evolutionarily primitive vertebrates including cartilaginous fishes, chondrosteans and holosteans. Immunoglobulin genes of the lake sturgeon were also studied by cDNA from erythrocytes followed by genomic analyses. Preliminary data showed that all actinopterygians probably possess heavy chain gene organizations similar to those of tetrapods, including mammals.

Anderson, E.R. 1984. Artificial propagation of lake sturgeon (*Acipenser fulvescens* Rafinesque), under hatchery conditions in Michigan. Mich. Dept. Nat. Res. Fish. Res. Rep. 1898: ix + 32 p.

The results of experiments on the artificial fertilization of lake sturgeon eggs, their culture, and the growth and survival of young under hatchery conditions were discussed. Adult sturgeon were collected with long-handled dip nets during their spawning migration in the upper Black River of Michigan. Milt was collected first, by drawing it into a 50cc syringe while stripping, and then stored on ice for 30 min prior to use. The caesarean section technique was used to obtain a total of 39,900 eggs from two ripe and running females. Eggs flowed freely from the incision and fertilization was started within five minutes of collection. Eggs and milt were mixed for 10 minutes and a suspension of bentonite clay powder was added several minutes later to prevent clumping. Fertilized eggs were incubated at 15°C, initially in MacDonald jars and later in vertical flow incubators with decreased flow rates prior to hatching, which occurred in nine days. Post-fertilization was complete in 24 hrs. Hatching success was 72% (for Michigan eggs) and 76% (for Wisconsin eggs) with a corresponding 26%

and 24% egg mortality due to fungal infection. Hatched sturgeon larvae transferred to holding tanks were negatively phototactic and swam constantly. The change from endogenous to exogenous feeding was accompanied by a behavioural change from negative to positive phototaxis and a general decrease in activity. Diet studies were carried out with sturgeon fry 16 days and 31 days post hatching. Two artificial semi-moist diets, OMP and Biodiet, were compared with a natural diet of zooplankton and an aquatic annelid species. The artificial diet treatments were divided into direct switch and weaned (i.e., gradually taken off their pre-treatment diet of zooplankton), while the natural diet treatment was only direct. Survival across treatments could not be compared with confidence since artificial diet fed sturgeon fry died by the 5th week while the survival of natural diet fed sturgeon was 54% (Wisconsin sturgeon) to 75% (Michigan sturgeon). Growth of sturgeon raised on the natural diet was greatest amongst all treatments with Biodiet second best, for any sampling point. At the termination of the experiment by week nine, natural diet fed sturgeon grew to an average of 84 cm (2.3 gm). Comparisons of growth across all treatments were only possible at the three week mark; the OMP-raised sturgeon grew least (averaging about 28 cm, 0.07 gm) compared to Biodiet (averaging about 29 cm, 0.08 gm) and natural diet (averaging about 38 cm, 0.25 gm).

Anderson, E.R. 1985. A partial bibliography of the sturgeon Family Acipenseridae. Mich. Dept. Nat. Res. Fish. Div. Fish. Res. Rep. **1936**: 22 p.

This bibliography contained 288 references divided into 6 sections; systematics and distribution, biology, management, morphology, physiology, and health aspects of the acipenserids. The biology and management sections were further divided into subsections. The biochemical and parasite literature of sturgeon was not covered in detail.

Anderson, E.R. 1986. Sturgeon: king of freshwater fish. Minn. Volun. **49**: 58-62.

This was an account of the natural history of the lake sturgeon in Minnesota. Sturgeon spawned there from late April to early June. Females reportedly matured between 24-28 years, with a 4-6 year interval between spawning. Males matured at 14-16 years and spawned in alternate years. The collapse of the sturgeon

fisheries and the attempts of the Michigan Department of Natural Resources to culture lake sturgeon are recounted. After years of trials, a five-year project was initiated in 1984 to restore lake sturgeon in the St. Louis River near Duluth. In 1985, 5,000 5-7 inch sturgeon were released after being wire tagged for future reference.

Anderson, E.R. 1987. Lake sturgeon (*Acipenser fulvescens*) management and culture in Minnesota and Michigan, p. 84. In C. H. Olver (ed.) Proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. **23**.

This three-year study on lake sturgeon included observations of pre- and post-spawning sturgeon and the collection of gametes. Eggs were removed by caesarean section and milt was removed with a syringe. Fry were fed zooplankton, aquatic annelids and artificial diets, but results were poor on the artificial diets. As part of a reestablishment program over 5,000 1-18 cm fingerlings were stocked into the St. Louis River. All of these fingerlings were code-wire tagged.

Anderson, J. 1956. The vanishing sturgeon. Ohio Cons. Bull. **20**: 13 & 32.

The declining number of lake sturgeon in Ohio waters was discussed. Indefinite closure of the fishing season was considered to have little value as a population management strategy. The prevention of pollution and soil erosion was recommended as an alternative that would restore clear water conditions and thereby improve sturgeon spawning success.

Anderson, P.J. 1971. The carboxy-terminal region of sturgeon muscle aldolase. Can. J. Biochem. **49**: 372-375.

Unmodified muscle aldolase was capable of cleaving fructose 1, 6-diphosphate (FDP) 20 times faster than fructose 1-phosphate (F-1-P). Results indicated that lake sturgeon muscle aldolase is different in its carboxy-terminal region from rabbit liver and brain aldolase.

Anderson, P.J. 1972. The number, location and reactivity of the cysteine residues of sturgeon muscle aldolase. Can. J. Biochem. **50**: 111-119.

Each subunit of lake sturgeon muscle aldolase contained six cysteine residues, which

apparently occurred in homologous positions to six cysteine residues of rabbit enzyme. Four of these six carboxymethylcysteine containing peptides were homologous with corresponding peptides in rabbit aldolase. Three residues reacted with iodoacetic acid in the absence of denaturing agents causing the inactivation of the enzyme. The presence of substrates protected one residue and no activity was lost. Results indicated that the loss of activity was due to the addition of modifying groups rather than the loss of sulphhydryl groups. It was considered unlikely that cysteine residues had a direct or an auxiliary catalytic role in aldolase activity.

Andrew, V.V., and Markov, G.S. 1971. Copper, zinc, and manganese content in the bodies of parasites of Acipenseridae. *Dokl. Akad. Nauk SSSR* 196: 82-84.

Polypodium contained significantly less copper, cobalt, and manganese than in the unparasitized sturgeon roe, but 2.1 times more zinc. *Amphiliina* contained 7-10 times more manganese, and 22-54% more zinc, than in the blood of Caspian sturgeon and sterlet, but less zinc in the Russian and giant sturgeons. *Contracaecum* and *Leptorhynchoides* contained 30-40 times more copper than their host intestine, and exceeded *Polypodium* in the content of the trace elements except zinc. The high concentration of zinc in *Polypodium* may have been an adaptation to the zinc requirements for enzymes and deoxynucleoproteids at the time of redistribution of DNA that took place in the final stages of the endoparasitic existence of *Polypodium*.

Anishinabek/Ontario Fisheries Resource Centre. 2004. Annual report 2004. A/OFR. 12 p. Available from www.aofrc.org/Annual%20Report%202004.pdf [accessed 30 March 2006].

Work completed by the A/OFR in 2003 was discussed. Two projects dealt with lake sturgeon spawning. In the first project gillnets were set near suspected spawning sites on the Serpent and Mississauga rivers. This project was unsuccessful at documenting spawning activity. The second project involved setting up gillnets near suspected spawning sites and spring habitats on the Spanish River. Spawning activity was not documented, however, adult and juvenile lake sturgeon were captured. This was the first documentation of lake sturgeon using

the Spanish River.

Anonymous. 1933. Mystery of sturgeon 41 solved. *Fisherman* 2: 12.

A 75 lb sturgeon branded with the number 41 was caught at the Newaygo Dam, Lake Michigan. A letter from Mr. Charles Trost informed officials that he had branded the sturgeon at Lake St. Clair 28 years prior to its capture at the dam. It weighed 41 lbs at the time, hence its brand.

Anonymous. [1970?] Experimental sturgeon rearing, 1970. Wolf Lake Fish Hatchery, Wisconsin. 3 p.

Approximately 50,000 lake sturgeon eggs were removed from the Wolf River, Wisconsin and transported to the Wolf Lake Fish Hatchery. Only 638 of the eggs hatched. The low hatch rate was attributed to fungal growth on clumped eggs. Treating with formalin could have controlled this problem. After hatching, accumulated silt, unhatched shrimp eggs, egg shells and dead shrimp caused the loss of 367 fry through smothering. Fry were initially fed brine shrimp and small plankton. As growth progressed, their diet was switched to lake run plankton, Chironomids, Tubificids and Annelids. Once they attained a length of 5 inches, attempts were made to rear them on an artificial diet of Oregon Moist pellets without success. Fifty, 3 inch lake sturgeon were placed in a pond, but upon drawdown after 135 days no fish were found to have survived.

Anonymous. 1993. A sturgeon management strategy for Manitoba. A discussion paper. Manitoba Department of Natural Resources, Manitoba. 25 p.

The history of lake sturgeon in Manitoba was discussed. The long term management goal of the Manitoba Department of Natural Resources was "To re-establish or maintain (at least at 1990 levels) sturgeon populations in Manitoba in balance with potential carrying capacity of its habitat" (pg. 5). The steps taken in developing the management strategy and guidelines and principles were outlined. High priority areas included the Nelson, Winnipeg, Churchill, Saskatchewan and Hayes rivers. Low priority areas included Round Lake, Hughes Lake, Lake Winnipeg and other scattered sturgeon populations. Waters in which the lake sturgeon

was traditionally found that are not included were the Red, Assiniboine and Roseau rivers, Lake Manitoba and Lake Winnipegosis. Current status, problems/issues, goals and required actions were outlined for each of the high priority areas.

Anonymous. 2000a. *Acipenser fulvescens* Rafinesque, 1817, p. 11-18. In Sixteenth Meeting of the CITES Animals Committee, Shepherdstown (United States of America), 11-15 December 2000. Doc. AC. 16.7.2.

North American distribution, habitat, ecology, threats, domestic use, international trade, conservation measures, and captive breeding of the lake sturgeon were discussed. The species is found in Alberta, Saskatchewan, Manitoba, Ontario and Québec. It is usually found in shoal areas of larger lakes and rivers, and requires fast currents and large, rough substrates for spawning and incubation. Dam construction and the associated habitat loss were noted as the main threat to the lake sturgeon in Canada. Recreational and commercial catch statistics are discussed. The lake sturgeon was listed on CITES Appendix II in 1975, delisted in 1983, and relisted in 1997. International trade statistics were briefly discussed. At the time of writing, lake sturgeon were listed under provincial regulation as "threatened" in Alberta, Manitoba, New Brunswick, Newfoundland, Ontario, Québec and Saskatchewan. Regulations and conservation measures were discussed by province/state. In Manitoba, the possession limit was reduced to zero in 1995. All commercial fisheries closed in the 1990s. Catch and release angling and aboriginal subsistence harvest were still allowed.

Anonymous. 2000b. Annual report on lampricide registration and re-registration activities and research May 2000. United States Fish and Wildlife Service, Sea Lamprey Control. 4 p.

This document was not available for annotating.

Anonymous. 2000c. Minnesota's sturgeon resurgence. Fish and Wildlife Today **November/December:** 4 p. Available from http://www.dnr.state.mn.us/fwt/back_issues/november00/article3.html [accessed 30 March 2006].

This popular article discussed the history of the

lake sturgeon in Minnesota and current recovery efforts.

Anonymous. 2000-2005. Sea lamprey Integration Committee meeting **00-01 – 05-01.** United States Fish and Wildlife Service, Sea Lamprey Control. [Series].

This interagency committee advises the Great Lakes Fishery Commission on sea lamprey related issues. Sea lamprey control may affect lake sturgeon in regions where they co-occur. These documents were not available for annotating so it is not known if they pertain to lake sturgeon.

Anonymous. 2001a. Annual report on lampricide registration and reregistration activities and research May 2001. United States Fish and Wildlife Service, Sea Lamprey Control. 4 p.

This document was not available for annotating.

Anonymous. 2001b. Report of the SWG Aquatic Committee on achieving action items identified in the Lake Superior LaMP 2000. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 2 p.

This document was not available for annotating.

Anonymous. 2001c. Sea lamprey management and the protection of lake sturgeon: points of agreement. United States Fish and Wildlife Service, Sea Lamprey Control. 3 p.

This document was not available for annotating.

Anonymous. 2002a. Advisor briefing book for GLFC annual meeting, June 3-4, 2002. United States Fish and Wildlife Service, Sea Lamprey Control. 4 p.

This document was not available for annotating.

Anonymous. 2002b. Five years of successful efforts in biodiversity. Le Fleuve 13: Pagination unknown. Available from http://www.slv2000.qc.ca/bibliotheque/lefleuve/vol13no4/bilan_biodiversite_a.htm [accessed 30 March 2006].

This article discussed results achieved under the St. Lawrence Vision 2000 Action Plan, one of

which was the Vianney Legendre fish pass. Completed in 2001 at the St. Ours Dam on the Richelieu River, this structure allowed the passage of 5 at risk species, including the lake sturgeon. Conservation measures implemented for Atlantic sturgeon were also discussed.

Anonymous. 2003a. FY-02 lake sturgeon production (Region 4). United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

Anonymous. 2003b. Lake sturgeon status assessment, monitoring, research and management projects in the Lake Michigan basin (January 2003). United States Fish and Wildlife Service, Sea Lamprey Control. 6 p.

This document was not available for annotating.

Anonymous. 2003c. Terms of reference for the Lake Sturgeon Task Group of the Lake Michigan Committee. Great Lakes Fishery Commission, Lake Michigan Committee, Ann Arbor, MI. 2 p.

Membership, agency commitment, function and scope, objectives, coordination, and frequency of meetings were outlined for the Lake Sturgeon Task Group of the Lake Michigan Committee. Their objectives were four in number and included the review of current stocking proposals in light of stocking issues identified by the Great Lakes Fishery Trust sponsored workshop and other relevant documents; the review of rehabilitation research needs, particularly those eligible for funding by the Great Lakes Fishery Trust; to identify and recommend lake sturgeon management and research issues; and to develop lake sturgeon public information and education initiatives.

Anonymous. 2004a. 2004 Lake Sturgeon Committee strategic action plan - summit. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 4 p.

This document was not available for annotating.

Anonymous. 2004b. Biology and management of lake sturgeon in the Kaministiquia River, Ontario (draft). United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 21 p.

This document was not available for annotating.

Anonymous. 2004c. Evaluation of lake sturgeon movements in the east fork Chippewa River using radio telemetry. United States Fish and Wildlife Service, La Crosse Fishery Resources Office, Fort Snelling, MN. 20 p.

This document was not available for annotating.

Anonymous. 2004d. Lake sturgeon management - sportfish restoration status reports, July 2003 - June 2004. Wisconsin Department of Natural Resources, Madison, WI. 7 p.

This document was not available for annotating.

Anonymous. 2005a. Guidelines for genetic conservation, propagation and stocking of lake sturgeon in Lake Michigan. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 18 p.

This document was not available for annotating.

Anonymous. 2005b. Manitoba's lake sturgeon endangered. *Fish News* 4: 3.

This short article discussed the review process of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as it related to lake sturgeon in Manitoba.

Anonymous. 2005c. State of the Great Lakes 2005 - status of lake sturgeon in the Great Lakes (draft). United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 4 p.

This document was not available for annotating.

Anonymous. 2005d. A survey of lake sturgeon status and stocking success in the Menominee River below Sturgeon Falls. Final Report to the Wilderness Shores Implementation Team. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 7 p.

This document was not available for annotating.

Anonymous. 2005e. Technical operating procedure - protocol for application of lampricides to streams with populations of

young-of-year lake sturgeon (*Acipenser fulvescens*). United States Fish and Wildlife Service, Sea Lamprey Control. 4 p.

This document was not available for annotating.

Anonymous. Date unknown. Lake sturgeon 2001 year class production (Region 4). United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

Anonymous. Date unknown. Lake sturgeon rehabilitation within the Bay of Quinte. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 32 p.

This document was not available for annotating.

Anonymous. Date unknown. Menominee Reservation lake sturgeon management plan. United States Fish and Wildlife Service, La Crosse Fishery Resources Office, Fort Snelling, MN. 10 p.

This document was not available for annotating.

Anonymous. Date unknown [2000?]. Minutes Lake Huron Technical Committee meeting 2000. United States Fish and Wildlife Service, Sea Lamprey Control. 21 p.

This document was not available for annotating.

Anonymous. Date unknown. Overview of 2002 lake sturgeon hatching and rearing at the Tennessee Aquarium Research Institute. United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

Anonymous. Date unknown. Review of 2004 lake sturgeon rearing at the Tennessee Aquarium Research Institute (TNARI). United States Fish and Wildlife Service, Atlanta, GA. 1 p.

This document was not available for annotating.

Anonymous. Date unknown. Species account, Acipenseridae for New York state. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 4 p.

This document was not available for annotating.

Anonymous. Date unknown. White Earth Reservation lake sturgeon management plan. United States Fish and Wildlife Service, La Crosse Fishery Resources Office, Fort Snelling, MN. 6 p.

This document was not available for annotating.

Anthony, D.D. 1974. Helminth parasites of sturgeon (*Acipenser fulvescens*) from Lake Nipissing, Ontario, Canada, p. 1642-1643. *In* Proc. 3rd Int. Congr. Parasitol. [Abstract only].

The heads and viscera of one hundred lake sturgeon were collected from Lake Nipissing, Ontario, between June, 1969 and October, 1973, and examined for parasites. Five species were found: *Diclybothrium armatum* was found on the gills (range=1-100 worms with a "median" intensity of 40.5 and 100% prevalence); *Skrjabinopsolus manteri* from the stomach (mean intensity of 0.48, range=0-8); *Crepidostomum lintoni* from the intestine (range=0-200, "median" intensity=61); *Cucullanus clitellarius* from the intestine (range=0-22, mean intensity=3.4); *Spinitectus* from the stomach (range=0-115, mean intensity=11.3). Two forms of the monogeneans were reported, one fitting the description of *Diclybothrium* and another resembling *Paradiclybothrium*. A variant of the typical *Crepidostomum lintoni* was also suggested as a different species. All of the fish were infected with *Diclybothrium* and 12% of the fish were infected with all five species of parasite. All species were first records for Lake Nipissing. *S. manteri* and *C. clitellarius* were the only records from Canadian sturgeon and *Spinitectus* was claimed to be the first record of this parasite from sturgeon.

Anthony, D.D. 1977. A new species of *Spinitectus* (Nematoda: Rhabdochonidae) from lake sturgeon (*Acipenser fulvescens*) from Lake Nipissing, Ontario, p. 70-71. *In* Program Abstr. 52nd Annual Meet. Am. Soc. Parasitol. Abstr. Vol. 178. [Abstract only].

A form of *Spinitectus* was reported from lake sturgeon. Cuticular spination extended over the entire length of the body of females but was present only in the anterior third of males. Gravid females were 8.0-10.2 mm long, and males were between 5.5 and 6.0 mm. The ratio

of the muscular esophagus to the glandular portion (1:3), the ratio of the esophagus to the entire body length (1:6), the position of the vulva, 10 pairs of the pedunculated papillae, and the spiralled form of the posterior end of the male were considered distinctive characters. No name was given to "new species" but it was considered morphologically closest to *S. gracilis*.

Armstrong, K. 1988. Identification of critical life history periods of lake sturgeon and factors that may affect population survival. Ontario Ministry of Natural Resources, Lake of the Woods Fisheries Assessment Unit, Kenora, ON. Pagination unknown.

This document was not available for annotating.

Armstrong, K. 1989. Lake sturgeon (*Acipenser fulvescens*) research needs for northern region. Ontario Ministry of Natural Resources, Lake of the Woods Fisheries Assessment Unit, Kenora, ON. Pagination unknown. [Unpublished]

This document was not available for annotating.

Arnold, D.E. 1971. Lake Erie alive but changing. *Conservationist* 25: 23-30 & 36.

The natural phenomenon of eutrophication following pollution was reviewed and the author discussed the geological past and future trends affecting this lake. The lake waters were characterized by heavy sedimentation loads, resulting from pollution by silt, domestic sewage and industrial waste. The latter included thermal, mercury and radioactive waste. Increases in Ca, Mg, SO₄, Na, K, Si, Cl, NO₃, PO₄, soluble P, organic N₂, and total solids were documented with actual values. Increases in total sedimentary P and ammonia nitrogen were also quantified. Some valuable commercial fishes had been extirpated from commercial catches including the lake sturgeon. However, the decline of the lake sturgeon was attributed mainly to systematic destruction by fishermen when it was considered a nuisance fish and its worth as a food fish was unknown. Restocking and restoring the polluted waters to their former pristine state were advocated as the means of returning the lake to its former status.

Artyukhin, E.N. 1995. On biogeography and relationships within the genus *Acipenser*. *The Sturgeon Quarterly* 3: 6-8.

The endemic zones of different groups of sturgeon were discussed. All of these zones were generally isolated with few connecting corridors. The author proposed a new phylogenetic tree reflecting relationships between acipenserids using a variety of distinguishing characteristics. He noted that the position of *Huso* was still unclear, although he suggested that it should have been placed within the genus *Acipenser*. *Huso* most closely resembled the *Acipenser* subgenus *Sterleta* by having numerous very small scutes, large strong pectoral fins, smooth skin with minute denticles, similar body shape, and fringed depressed barbels.

Artyukhin, E.N., and Andronov, A.E. 1990. A morphological study of the green sturgeon, *Acipenser medirostris* (Chondrostei, Acipenseridae), from the Tumnin (Datta) River and some aspects of the ecology and zoogeography of Acipenseridae. *J. Ichthyol.* 30: 11-21.

This article discussed the morphology of the green sturgeon and the zoogeography of acipenserids in general. It was noted that the freshwater systems in which lake sturgeon reside seem to enable them to be more resistant to population decline due to their large area and separation of feeding and spawning grounds. This allows for the formation of large ranges and many local populations, increasing the chances for gene pool preservation. This would also hold true for populations subject to human disturbance.

Asch, M., and Macklem, P. 1991. Aboriginal rights and Canadian sovereignty: an essay on *R. v. Sparrow*. *Alberta Law Review* XXIX: 498-517.

This article examined the landmark case of *R. v. Sparrow*. The case involved aboriginal fishing rights, specifically, whether the Musqueam Nation of British Columbia had the right to fish without being constrained by federal regulations (fishing permit required and gear restricted to a drift net not exceeding 25 fathoms in length). The Court found in favour of the Musqueam Nation. The basis for this decision was examined and alternatives presented.

Atkinson, J.R. 1987. Management of lake sturgeon (*Acipenser fulvescens*) as a sport fish in Ontario, p. 91-94. In C. H. Olver (ed.)

Proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23.

Recommendations for the management of lake sturgeon as a sport fish were presented. The daily creel limit of one fish per angler per day was recommended to be reassessed. Female sturgeon had the potential to spawn 3-4 times between the ages 20-40 and spawned less regularly than males, thus a minimum size limit was urged. Since sturgeon were still concentrated and readily caught when the season opened, the opening date of the sport fishery was recommended to be delayed to enable sturgeon to disperse. Other recommendations included the need for more data on the biology of lake sturgeon, a survey to assess its popularity, its promotion as a trophy fish, the completion of experimental trials of size limits on selected populations, and the possibility of stocking through intensive culturing.

Auer, N.A. 1992. Conservation of the threatened lake sturgeon. Prepared for 1992 Nongame Wildlife Fund and Living Resources Small Grants Program, Michigan Department of Natural Resources. 23 p. + app.

The objective of this study was to examine a lake sturgeon population spawning near the Prickett hydroelectric facility on the Sturgeon River, Michigan. Each spring, the sturgeon migrate 69 km up the Sturgeon River to spawn in a 2.7 km section below the facility. In the last two years of the study, 1991 and 1992, the operation of the facility changed from a peaking facility (produces electricity during peak hours of use) to a run-of-the-river operation (tries to match plant discharge with natural flow of the river above the reservoir). The results from the 1992 study year are compared with results from the previous five years of study. In 1992, 121 adult lake sturgeon were captured using dipnets, tagged and released. Of these, 52 were female, 65 male and 4 undetermined. Weight ranged from 5 kg to 41 kg, and total length ranged from 99 cm to 181 cm. Length and weight frequency distributions by sex are presented and recapture data is summarized. The main changes observed in the lake sturgeon population due to the change in facility operation are discussed. These include: a change in the length of time adult lake sturgeon were observed on the site (reduced from 2-3 months to 2-3 weeks), a change in the area of fish capture, an increase

in the number of individuals tagged, an increase in the number of females, an increase in the number of fish in "ripe-running" condition, an increase in the number of larger fish, and increase in evidence of spawning. Management recommendations are included. The author concludes that the altered flow regime appears to be beneficial to sturgeon survival.

Auer, N.A. 1994a. Assuring a long-lived species a place in the 21st century, p. 9. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Auer, N.A. 1994b. Effects of change in operation of a small hydroelectric facility on spawning characteristics of lake sturgeon. *Lake Reservoir Manag.* 9: 52-53. [Abstract only].

Lake sturgeon spawning below a small hydroelectric facility on the Sturgeon River altered their spawning behaviour in response to the facility operating at its peak. There was a reduction in the time adult lake sturgeon were observed on the site, an increase in the total number and size of adults, an increase in spawning-ready fish, and a change in the location of capture. The author argued that the constant water flows triggered the reproductive readiness and allowed larger fish to migrate to spawning grounds. These beneficial findings should be applied to other facilities in order to improve the use of water resources.

Auer, N.A. 1995. Life history strategies of lake sturgeon, *Acipenser fulvescens*, in the Sturgeon River - southern Lake Superior ecosystem. Ph.D. Thesis, Michigan Technological University, Houghton, MI. Various pagination.

This was a thesis consisting of four chapters. The first chapter discussed biological characteristics of spawning lake sturgeon before, during, and after changes in the operation of a hydroelectric facility. The second chapter discussed the historic and general importance of migration to all species of sturgeon. Chapter three dealt with spawning periodicity, movement, and range of post-spawning adult lake sturgeon at the Sturgeon River. Chapter four dealt with historic and current status of lake sturgeon in the Great Lakes region.

Auer, N.A. 1996a. Importance of habitat and migration to sturgeons with emphasis on lake sturgeon. *Can. J. Fish. Aquat. Sci.* **53**: 152-160.

Some sturgeon exhibited a positive relationship between spawning migration distance and average adult size. Lake sturgeon endemic to the Great Lakes basin were restricted in movement, with only a few free-ranging populations left. Management plans should be developed from information based on these free-ranging populations. The author suggested a barrier-free lake and stream range of 250 to 300 km as a minimum to support a self-sustaining lake sturgeon population, but recommended a distance of 750-1,000 km. Barrier removal or fish passage should be given more attention than habitat improvement for isolated or constrained populations.

Auer, N.A. 1996b. Response of spawning lake sturgeons to change in hydroelectric facility operation. *Trans. Am. Fish. Soc.* **125**: 66-77.

Lake sturgeon spawning was studied from 1987 to 1992 below the Prickett hydroelectric facility on the Sturgeon River, Michigan. Changes in spawning behaviour were noted at different water flow levels. Under relatively natural flow conditions, the fish were observed 4 to 6 weeks less at spawning grounds, 74% more fish were observed, 68% more females were present, and fish were noted as having increased reproductive readiness when compared to reduced water flow conditions. Similar positive results should be expected in other areas of comparable water regulation systems.

Auer, N.A. 1999a. Lake sturgeon: a unique and imperilled species in the Great Lakes, p. 515-536. *In* W.W. Taylor and C.P. Ferreri (ed.) *Great Lakes fisheries policy and management: A binational perspective*. Michigan State University Press, East Lansing, MI.

The diet, life history, commercial and subsistence fisheries, and status of lake sturgeon in the Great Lakes were discussed. Physical impacts to habitat, migration barriers, and fishing effects were identified as the main reasons for the decline of lake sturgeon. Management issues identified include stock identification and genetic diversity, range restrictions and habitat degradation, fishery conflicts, by-catch and poaching, sea lamprey management, and contaminants.

Auer, N.A. 1999b. Population characteristics and movements of lake sturgeon in the Sturgeon River and Lake Superior. *J. Gt. Lakes Res.* **25**: 282-293.

The Sturgeon River spawning population was studied from 1987 to 1995 using radio-tracking technology. Information was collected on the range and habitat use of post-spawning sturgeon. Telemetry data from 25 fish were supplemented with data from identification tag returns. Of the 925 fish studied, 86 returned to spawn once, and 12 returned to spawn twice. Male sturgeon spawning intervals were slightly shorter than female intervals, being 2-4 years and 3-7 years respectively. Males were never seen spawning in consecutive years. In 1995, the male-female sex ratio at the spawning site was 1.25:2.7. Identification tag returns revealed that lake sturgeon traveled from 70 to 280 km from the spawning site throughout Lake Superior.

Auer, N.A. (ed.) 2003. A lake sturgeon rehabilitation plan for Lake Superior. *Gr. Lakes Fish. Comm. Misc. Publ.* **2003-02**: 28 p. Available from www.gllfc.org/pubs/SpecialPubs/2003_02.pdf [accessed 30 March 2006].

This report outlined a rehabilitation plan for lake sturgeon in Lake Superior. The goal was "to maintain, enhance and rehabilitate self-sustaining populations where the species historically occurred basin-wide." Nine Lake Superior tributaries were identified as having self-sustaining lake sturgeon populations. These included the: Sturgeon River in Michigan; Bad River in Wisconsin; and Big Pic, Black Sturgeon, Goulais, Gravel, Kaministiquia, Michipicoten, and Nipigon rivers in Ontario. The decline of lake sturgeon since the mid-1800's, difficulties with rehabilitation and critical Lake Superior management areas were discussed. Management strategies included harvest controls, protection and rehabilitation of habitat, studying population biology and genetics, increased assessment, development of a reliable egg source, regulated stocking, and public education. Each of these strategies was discussed in detail.

Auer, N.A., and Baker, E.A. 1997. Drift of larval lake sturgeon in the Sturgeon River, p. 457. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating

Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Auer, N.A., and Baker, E.A. 2002. Duration and drift of larval lake sturgeon in the Sturgeon River, Michigan. *J. Appl. Ichthyol.* **18**: 557-564.

The extent and duration of larval drift in lake sturgeon populations was studied to aid efforts to restore and rehabilitate lake sturgeon stocks. The most vulnerable stage in the life cycle of lake sturgeon was believed to be from egg to 250 mm total length. Larval drift was monitored for 8 years using drift nets set 14, 26, 35, 45, and 61 km below a spawning site on the Sturgeon River. A total of 978 larvae were collected over the study period. Results indicated that lake sturgeon larvae drifted 26 river kilometres below the spawning site 15 to 27 days after spawning and 45 river kilometres 25 to 40 days after spawning. The average size of the larvae increased with distance downstream and they were not distributed evenly through space and time. The two peaks in spawning seemed to be related to the phase of the new moon in years with no heavy spring flows. The lower Sturgeon River may be an important habitat for young-of-the-year sturgeon.

Auer, N.A., and Holtgren, J.M. 2000. Movement and habitat utilization of juvenile lake sturgeon in Portage Lake, Michigan. *In* 130th AFS Annual Meeting, St. Louis, MO. 20-24 August, 2000. Reflections. Pagination unknown. [Abstract only]. Available from http://www.ecu.edu/org/afs/St_Louis/abssturgeon/r951340632-46.htm [accessed 30 March 2006].

Auer, N.A., Lepara, F.A., and Baker, E. 2004. Assessment of remnant lake sturgeon populations in five Lake Michigan tributaries 2002-2003, with emphasis on physical river characteristics. Final report to the Great Lakes Fishery Trust. Project Number 2001.113. Michigan Technological University, Department of Biological Sciences, Houghton, MI. 32 p.

This document was not available for annotating.

Avelallemant, S., Czeskleba, D.J., and Thuemler, T. 1983. Artificial spawning and rearing of lake sturgeon at the Wild Rose State Hatchery, Wisconsin. *Wis. Dept. Nat. Res. Madison, Fish Cult. Note* **5**: 7 p.

Eggs and sperm were collected from actively spawning fish captured by dip netting. Milt was removed with a syringe and eggs were recovered following caesarean section. Eggs were fertilized immediately, returned to the hatchery, treated to remove clumps and then incubated at 13°C and 16°C. Hatching success was 63.5% at 13°C and 55% at 16°C after eight days. The greater hatching success rate may be related to lower fungal levels at 13°C. Newly hatched fry were negatively phototactic up to 10 days post-hatch and then became positively phototactic. Fry preferred live brine shrimp over dry feed. Frozen *Daphnia* and brine shrimp were marginally acceptable foods. Fry produced gas bubbles in tubs at 21 days and were moved to raceways with a water flow of 12.5 gal/min. Fry and fingerlings were treated with chloramine-T-hydrate at concentrations increasing from 10 ppm to 16 ppm. Wild fingerlings captured in the Wolf River grew faster than hatchery-reared fingerlings.

Axelsen, F., and Mauger, A. 1993. Sturgeon holding cage trials on Lake Opawica and Lake Lichen. Ministère de l'agriculture, des pêcheries et de l'alimentation du Québec. Direction de la recherche scientifique et technique Doc. rech. **93/06**: iv + 42 p.

Holding cages were tested as a means of keeping sturgeon alive while awaiting transport to a processing plant. This was compared to the traditional method of tying them by the tail and keeping them alive until transportation is arranged. A detailed design of the holding cage is given. The trials were carried out on lakes Opawica and Lichen in Québec. On Lake Opawica the sturgeon tied by the tail had an average weight loss of 9.2% and exhibited physical signs of stress (blood marks from tail to snout likely caused by constriction of the blood vessels in the tail). The processed flesh was also darker than that of the sturgeon kept in cages. Twenty-six of 27 sturgeon tied by the tail survived. Sturgeon in holding cages had an average weight loss of 6.2% and showed no visible signs of stress with the exception of blood marks on the ventral side of a few (caused by rubbing against the cage). However, 20 of 41 fish in the holding cage died. It was hypothesized that this was due to overcrowding. On Lake Lichen a larger holding cage was used to test the overcrowding theory. Lake Lichen sturgeon tied by the tail had an average weight loss of 10% and all survived. Of the 8 sturgeon

placed in the holding cage all survived and showed an average weight loss of 5.7%, with 20% of the sturgeon gaining weight. The authors conclude that overcrowding was the likely cause of the high mortality in the Lake Opawica trial.

Bailey, R.M., and Smith, G.R. 1981. Origin and geography of the fish fauna of the Laurentian Great Lakes basin. *Can. J. Fish. Aquat. Sci.* **38**: 1539-1561.

This article described the evolution of the Great Lakes since the last glaciation, and various aquatic refugia and routes used by fish species. Lake sturgeon were identified as being native to the Great Lakes and found in lakes Superior, Michigan, Huron, St. Clair, Erie, and Ontario and their tributaries, as well as in Lake Nipigon. Refugia and access routes identified for lake sturgeon included St. Croix, Fox, Chicago, and Maumee rivers.

Bain, M. (principal investigator). 1993. Sturgeon Notes. Sponsored by the Hudson River Foundation, Cornell University, Ithaca, NY. **1**: 6 p. [Newsletter].

Summaries of research regarding different species of sturgeon were presented.

Bain, M. (principal investigator). 1996. Sturgeon Notes. Sponsored by the Hudson River Foundation, Cornell University, Ithaca, NY. **4**: 17 p. [Newsletter].

Summaries of research regarding different species of sturgeon were presented.

Bajkov, A.D. 1933. Report on fisheries investigations, sturgeon - Pigeon River. Man. Dept. Mines Nat. Res. MS. Rep. 15 p.

The Pigeon River in Manitoba was investigated for sturgeon distribution from the river mouth to Sturgeon Falls, 14 miles upstream. Seventy five 10-12 inch mesh nets were set two weeks prior to May 27th. A total of 14 lake sturgeon were caught of which 12 were males and two were unripe females. There was evidence for illegal fishing and sturgeon stocks were thought to be considerably depleted. The report was accompanied by photographs showing sturgeon spawning sites on the Pigeon River and some fishing in action.

Bajkov, A.D., and Neave, F. 1930. The sturgeon and sturgeon industry of Lake Winnipeg, p. 43-47. In *Canadian Fisheries Manual*. National Publications Ltd., Gardenville, Québec.

The distribution, biology, and fishery production were outlined. There were suggestions of dimorphism in lake sturgeon populations based on snout shape. The sturgeon at this time occurred in Lake of the Woods, Lake Winnipeg system, and the Winnipeg, Saskatchewan, and Nelson rivers. They also occurred in the Red and Assiniboine basins but were absent from the western shores of Lake Winnipeg, Lake Winnipegosis, Dauphin Lake and Lake St. Martin. The authors suggested that sturgeon preferred water that was not strongly alkaline (i.e., pH of not more than 8.0). In Lake Winnipeg sturgeon were caught in shallow water (4-5 ft) in June but later in the summer were found in water up to 7 fathoms deep. Some evidence suggested that fish feeding in shallow water were the darker coloured, blunt-nosed sturgeon. They had been seen feeding amongst wild rice in 1-2 ft of water. Food items were variable with the fish fly *Hexagenia limbata* being the most common. Females grew faster than males and females lost about a third of their weight after spawning (roe and fat). The decrease of sturgeon populations in North America was due to extensive fishing coupled with slow growth. Prohibition of fishing, even for ten years, would only delay the collapse of a fishery. The authors recommended the protection of the young and of remaining large individuals, as well as the creation of special reserves comprising spawning grounds and lakes, with total prohibition of fishing in such areas.

Baker, E. 2004. Evaluation of lake sturgeon (*Acipenser fulvescens*) populations in northern Michigan. United States Fish and Wildlife Service, Federal Aid Region 3 Study Performance Report # **F-81-R-5**: 2 p.

This document was not available for annotating.

Baker, E.A., and Borgeson, D.J. 1999. Lake sturgeon abundance and harvest in Black Lake, Michigan, 1975-1999. *N. Am. J. Fish. Manag.* **19**: 1080-1088.

The lake sturgeon population in Black Lake, Michigan was sampled from May to July of 1997 to assess the state of the population. Estimation

of population size was completed using the Schnabel method. Harvest data from voluntary registration of spear fishing from 1975 to 1999 was used to assess its effects since establishment in 1948. One hundred and ninety-two lake sturgeon were tagged over 24 sample periods. Total lengths ranged from 75 to 193 cm and ages from 9 to 64 years. The authors determined that there had been a 66% decrease from the 1975 estimate of the harvestable fish population based on length frequency analysis. Regression analysis showed that if this trend continued, harvests would be near zero by the year 2011. Average weight and length of the harvest had increased over the same time period, showing that recruitment was not sufficient to balance the current harvest level. The authors predicted that 40% of the population decline was the result of legal harvest. The remaining 60% was likely due to illegal harvest, wounding mortality from spearing, and natural mortality. Restrictive harvesting legislation was being introduced in 2000 to prevent this population from being extirpated.

Baker, J.P. 1980. The distribution, ecology, and management of the lake sturgeon (*Acipenser fulvescens* Rafinesque) in Michigan. Mich. Dept. Nat. Res. Fish. Div. Fish. Res. Rep. 1983: viii + 95 p.

Sturgeon populations in the following lakes and waterways of Michigan were investigated: Burt, Mullet, and Black lakes, Lake St. Clair, and the Menominee and St. Clair rivers, where the populations were significant; and Otter, Manistique, Indian, Brevort, and Monacle lakes which harboured remnant landlocked populations of lake sturgeon. The population of lake sturgeon 48.6 inches and larger in Black Lake was estimated to be 1,599 in 1975 with a 2.1% exploitation rate in 1976. The natural mortality rate was calculated to be 0.076, using a standard exploitation rate of 2.5%. The mean annual recruitment to the fishable stock was 4.5% with the age at entry into the fishery held constant at 22 years. The maximum catch limit was calculated to be 77 fish. The growth rates of sturgeon from Black and Mullet lakes and the Menominee River were very similar. Recommendations for protecting sturgeon stocks included strict enforcement of poaching regulations, prohibition of sturgeon fishing statewide during May and June, and the season creel limit reduced from two to one fish.

Baker, J.P. 1982a. The fish with the golden egg. Mich. Nat. Res. Mag. 51: 50-57.

This popular article gave a general account of the history of sturgeon fishing in North America and described the life history of this species. The best known sturgeon populations in Michigan apparently occurred in Burt, Mullet and Black lakes and in the Cheboygan River system of the northern Lower Peninsula. Smaller sturgeon populations were also present in Otter, Manistique, Indian, Brevort and Monacle lakes. It was urged that the remaining feeding and spawning habitats of lake sturgeon be carefully protected, poaching be strictly controlled, and artificial propagation methods be employed to revive sturgeon stocks. The article contained, on its first two pages, an impressive colour photograph of a swimming lake sturgeon.

Baker, J.P. 1982b. Yield per recruitment of inland stocks of lake sturgeon (*Acipenser fulvescens* Raf.) in Michigan. Mich. Acad. 14: 415-425.

This was a report on the analysis of sturgeon harvest data from Black and Mullet lakes and the Menominee River of Michigan. The parameters for the von Bertalanffy equation for Michigan sturgeon were calculated as: $L_{\infty} = 69.6411$ inches, $k = 0.0558$ and $x_0 = -0.8815$. The length-weight relationship was given by the equation $\ln W = -8.8949 + 3.1393 \ln L$ where W is weight in pounds and L is length in inches. Rates of instantaneous total mortality were determined by analyzing the catch curves for the Black Lake and Menominee River fish separately. Instantaneous total mortality was 0.102 and 0.098 for Black Lake and the Menominee River, respectively. The annual total mortality (0.097 and 0.093) for each of these systems was similar. Based on the yield model, total biomass of an unharvested spawning population was 70,276 pounds per 1,000 age-1 recruits. With an exploitation rate of 2.5% and 22 years as the age at entry into the fishery, the total biomass showed a 32% decline. The annual mortality rate of sturgeon was considered to be very small. The continued close monitoring of sturgeon fisheries was recommended.

Baker, R.F. 1989. An environmental assessment and biological investigation of the Nelson River estuary. Report by North/South Consultants Inc., Winnipeg for Manitoba Hydro, Winnipeg. MB. xv + 179 p.

This report presented the results of a multi-disciplinary biological study of the Nelson River estuary conducted during the open water season of 1988. Baseline data were collected on water chemistry, zooplankton, zoobenthos, and fish populations. A principal objective was to describe the physical, chemical and biological features of the estuary, prior to completion of the Limestone Generating Station and initiation of hydroelectric developments at Conawapa. A total of 126 invertebrate species and 27 fish species were identified from the estuary.

Baker, R.F. 1990. A fisheries survey of the Limestone Forebay, 1989 - Year I. North/South Consultants Inc., Winnipeg, Manitoba. vii + 58 p.

A fisheries survey was completed on the Limestone Reservoir, Nelson River in 1989. This was the report of the first year of a multi-year study to monitor changes in fish populations and life characteristics of fish in the new reservoir. The first objective was to determine species composition, relative abundance, and biological parameters of fish. The second was to complete a mark-recapture study to examine fish movements and population levels in the forebay. Data were collected on fish species composition and abundance, size, age, mortality, diet, and mercury levels. Of the 1,759 fish captured, lake sturgeon were listed as comprising 0.3% and 0.6% in the Limestone forebay in 1989 and the Nelson River mainstem in 1988, respectively.

Baker, R.F. 1991. A fisheries survey of the Limestone Forebay, 1990 - Year II. North/South Consultants Inc., Winnipeg, Manitoba. vii + 56 p.

This was the report on the second year of a multi-year study described in the annotation above. Lake sturgeon were not captured in this study year.

Baker, R.F. 1992. A fisheries survey of the Limestone Forebay, 1991 - Year III. North/South Consultants Inc., Winnipeg, Manitoba. vii + 60 p.

A fisheries survey was completed in 1991 in the Limestone Forebay and the Nelson River. Of the 1,766 fish captured, lake sturgeon accounted for 0.3% and were all from the Limestone Forebay.

Baldwin, N.S., Saalfeld, R.W., Ross, M.A., and Buettner, H.J. 1979. Commercial fish production in the Great Lakes 1867-1977. pp. 6,

30, 31, 70, 84-85, 124-125, 158-159. In *Gr. Lakes Fish. Comm. Tech. Rep. 3*. Available from www.glfc.org/databases/commercial/commerc.p hp [accessed 30 March 2006]; updated periodically.

A year by year breakdown of commercial lake sturgeon production from the first to the last recorded harvest was provided in tabular form, separately for each of the 5 Great Lakes; Ontario, Erie, St. Clair, Michigan and Superior. Furthermore, a breakdown was provided for separate catch records for U.S. and Canada, and in some cases for U.S. states. In Lake Ontario, 546,000 pounds were harvested in 1879, the year of the first harvest record, of which Canada produced only 1,000 pounds. Canadian productions did not exceed 100,000 pounds except in 1882 (103,000 pounds). The highest total production was obtained in 1890 (581,000 pounds) followed by a decline, and after 1908 the harvest did not exceed 20,000 pounds except in 1930 (24,000 pounds). In 1977, the total harvest was 4,000 pounds. In Lake Erie, the 1879 production totalled 2,112,000 pounds, of which Canada (Ontario) harvested 142,000 pounds. Separate statistics for four different states (N.Y., Pennsylvania, Ohio and Michigan) were available for the first time in 1885. The combined harvest also reached its highest point that year, 5,187,000 pounds, of which N.Y. State harvested 3,723,000 pounds and Canada 459,000 pounds. One million pounds was reached only once more, in 1893, after which the fishery declined. In 1908, the total catch was 170,000 pounds. Commercial sturgeon fishing was banned in Canadian waters from 1920-1921 and in Michigan waters from 1929-1950. In 1968, Ohio closed its fishery. The Canadian harvest exceeded 500,000 pounds only in 1890; the combined harvest did not reach 100,000 pounds after 1916, and has remained under 50,000 pounds since 1929. In 1977, 5,000 pounds of sturgeon were harvested from Lake Erie. In Lake St. Clair, the highest production was attained in the first year of record (1879, 1,091,000 pounds). The harvest dropped to 278,000 pounds in 1885 and has not exceeded 100,000 pounds since 1893. No catches have been reported since 1969 (harvest of 17,000 pounds for the year), when discovery of mercury contamination in fish resulted in closure of the fishery. Canada's contribution was always less than 80,000 pounds except in 1879, the high-point of the fishery. Statistics are available for

Saginaw Bay in Michigan, Georgian Bay and the North Channel in Ontario, and Lake Huron proper separately for Michigan and Ontario. The largest harvest was taken in 1885 (1,041,000 pounds), after which production declined steadily and did not exceed 100,000 pounds after 1904. Commercial fishing was prohibited from Michigan waters from 1928-1950 and did not exceed 2,000 pounds thereafter. The Canadian contribution exceeded that of the U.S. after 1892 and all of the 9,000 pounds harvested in 1977 came from Canadian waters. There were no records of catches made in U.S. waters of Lake Huron after 1963. Lake Michigan attained its peak sturgeon harvest in the very first year of production records (3,840,000 pounds). One million pounds was exceeded only once more, in 1885, after which production declined rapidly to under 20,000 pounds after 1910. Separate production levels were provided for the waters of Michigan, Wisconsin, Illinois and Indiana. Michigan waters were closed to commercial fishing for lake sturgeon from 1929-1950 and other waters of Lake Michigan have been closed since 1929. Since 1953, the sturgeon harvest has not exceeded 3,000 pounds. The statistics for Lake Superior showed similar high initial production (224,000 pounds in 1884) followed by a decline to under 30,000 pounds after 1900. Commercial sturgeon fishing from Michigan's share of the waters was banned from 1928-1950 and has been banned in the two other states, Minnesota and Wisconsin, since 1928. The last harvest record was for 1976 when 1,000 pounds were taken, all of it in Canadian (Ontario) waters.

Ballard, W.W., and Ginsburg, A.S. 1980. Morphogenetic movements in acipenserid embryos. *J. Exp. Zool.* **213**: 69-103.

Morphogenetic movements, a timetable for involution, and a fate map for the blastulae of four species of Eurasian sturgeon were presented for the first time and found comparable to unpublished studies on lake sturgeon from Wisconsin in 1979. The close resemblance of holoblastic sturgeon embryos to frog embryos and their differences with meroblastic teleost embryos were discussed. The earliest movements at the surface involved the massive migration of inner cells of the blastocoel roof to an inner marginal zone. This was followed by the first drift of cells at the surface. A band of cells encircling 360° of the surface of the blastula from the equator up to the

20° latitude mark gave rise to the definitive endoderm lining, the archenteron, and their movement across the lip of the blastopore to the interior was termed involution. A complete band of both surface and inner marginal cells from 20° to 30° latitude produced notochord and somite mesoderm, also by involution. Mesoderm of the tail reached the interior before closure of the blastopore and head mesoderm, and intermediate and lateral plate mesoderm were not found in the surface region of the blastula.

Bangham, R. 1955. Studies on fish parasites of Lake Huron and Manitoulin Island. *Am. Midl. Nat.* **53**: 184-194.

One adult specimen of "rock sturgeon"-*Acipenser fulvescens* was examined from South Bay. The following parasites were recovered. *Crepidostomum lintoni*, *Cucullanus clitellarius*, *Diplobothrium hammulatum*, *Diplostomum* sp., *Echinorhynchus salmonis*. The author cited Bangham's (unpublished data) investigations of four rock sturgeon from Upper Lake Pepin. All were infected with *C. lintoni*, one with *Rhabdochona cascadiella* and two with a species of *Spinitectus*. Another "large" sturgeon captured in 1944 was infected with forty *C. lintoni* and hundreds of *D. hammulatum*.

Bangham, R.V., and Hunter, G.W. 1939. Studies of fish parasites of Lake Erie. Distribution studies. *Zoologica (N.Y.)* **24**: 334-339.

Two specimens of *Acipenser fulvescens* were examined from pond nets near Peele Isle. Both were infected with a small number of *Crepidostomum lintoni* and *Cucullanus clitellarius*, and one was infected with a species of *Allocreadium*.

Bansteev, V., Moran, K.L., Dixon, D.C., Trevithick, J.R., and Sivak, J.C. 2004. Optical properties, mitochondria, and sutures of lenses of fishes: a comparative study of nine species. *Can. J. Zool.* **82**: 86-93.

A comparative lense study was completed on seven teleosts (oscar, *Astronotus ocellatus*; smallmouth bass, *Micropetrus dolomieu*; orangespotted sunfish, *Lepomis humilis*; Arctic char, *Salvelinus alpinus*; common carp, *Cyprinus carpio*; rainbow trout, *Oncorhynchus mykiss*; American eel, *Anguilla rostrata*; brook lamprey, *Lampetra lamotteni*; and lake sturgeon,

Acipenser fulvescens). Teleost fishes had "line" features while "Y" sutures were seen in lake sturgeon lenses.

BAR Environmental Inc. 1995. Carmichael Falls hydroelectric project: year III of long term monitoring program. Prepared for Beaver Power Corporation, Oakville, ON. 63 p.

This document was not available for annotating.

Bardach, J.E., Ryther, J.H., and McLarney, W.O. 1972. Culture of sturgeon, p. 520-527. In *Aquaculture: the farming and husbandry of freshwater and marine organisms*. John Wiley & Sons, Inc., New York.

This account reviewed the early destructive practices of sturgeon fisheries with reference to North American sturgeons. The early attempts at artificial propagation were described and an overview (historical and recent) was provided on sturgeon culture in Russia, including a discussion on species used for fishery and culture, and a section on the prospectus of the world sturgeon fishery at present.

Barnickol, P.B., and Starrett, W.C. 1951. Commercial and sport fishes of the Mississippi River between Caruthersville, Missouri and Dubuque, Iowa. *Bull. Ill. Nat. Hist. Surv.* **25**: 288-290.

Lake sturgeon biology, commercial exploitation, and present distribution in the Mississippi River were discussed. From old accounts, the lake sturgeon was a common fish of the system but its numbers declined during the early 1900's and no sturgeon were caught while test-netting in 1944 and 1946, although one was caught in a hoop net by a commercial fisherman in 1946.

Barth, C.C. 2005. Lake sturgeon investigations in the Keeyask Study Area, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. xii + 115 p. [Keeyask Project Environmental Studies Program Report 02-19].

This report discussed the second year of lake sturgeon investigations in the Keeyask Study Area. The study was conducted to gather baseline information for an Environmental Impact Statement for the development of a hydroelectric generating station at Gull Rapids on the Nelson River. Sampling locations

included the Burntwood, Nelson, and Grass rivers, and Stephens Lake. The objectives were to examine lake sturgeon biology, identify spawning areas, determine abundance and habitat use, monitor movements, and determine if lake sturgeon ascend Birthday Rapids and/or Gull Rapids. Gillnets and larval drift nets were used to sample lake sturgeon and eggs and larvae. Radio and acoustic transmitters were used to monitor movements. A total of 92 lake sturgeon were captured, 67 from the Nelson River, 16 from the Burntwood River, 5 in the Nelson and Grass rivers and 4 in Stephens Lake. Seasonal habitat use and habitat characteristics were described.

Barth, C.C., and MacDonell, D.S. 1999. Lower Nelson River lake sturgeon spawning study Weir River, 1998. Prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. vi + 59 p.

Lake sturgeon were captured with gillnets in the lower 2.5 km of the Weir River from May 20 to June 25, 1998. All were measured for fork length, total length, and weight and were tagged with Floy disc tags. Sexual maturity was determined when possible. Wisconsin-style nets were employed to capture lake sturgeon eggs and larvae drifting downstream. A total of 232 lake sturgeon were captured; 157 were tagged, 2 were released without tags, and 73 were recaptures of fish tagged in previous years. Seventy-two of the recaptures had been tagged in the Weir River and 1 was tagged below the Long Spruce Generating Station spillway in 1989. One lake sturgeon, tagged in the Weir River in 1996, was recaptured in the Hayes River in July of 1998. This sturgeon had migrated down the Nelson River, into Hudson Bay, and up the Hayes River. This was the first recorded movement of sturgeon between the Hayes and Nelson rivers and extended the range of sturgeon that spawn in the Weir River. One hundred and eighty-three were identified as male, 27 female, 13 immature, and 9 as unclassified. The first ripe male was captured on May 24 and the last ripe male was captured on June 13. The first spent males were captured on June 10. Other species captured included walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*), longnose sucker (*Catostomus catostomus*), and freshwater drum (*Aplodontilus grunniens*). A total of 82 lake sturgeon eggs were captured, beginning on June 9. The peak catch (42 eggs) occurred on June 11. The last

sturgeon eggs were captured on June 16. A total of 93 lake sturgeon larvae were captured, beginning on June 14. Peak catch (34 larvae) occurred on June 15. Peak lake sturgeon catch occurred between May 22 and 23 and June 8 and 12 at water temperatures of 10.5°C and 17°C, respectively. It appeared that spawning occurred between June 8 and 14 at water temperatures between 16.5°C and 17°C, and peak spawning appeared to occur on June 9 and 10 at a water temperature of 17°C. Results are compared to those from previous years.

Barth, C.C., and Mochnac, N.J. 2004. Lake sturgeon investigations in the Gull (Keeyask) Study Area, 2001. Draft Report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. xvi + 130 p. [Gull (Keeyask) Project Environmental Studies Program Report 01-14].

This report discussed lake sturgeon investigations in the Keeyask Study Area. The study was conducted to gather baseline information for an Environmental Impact Statement for the development of a hydroelectric generating station at Gull Rapids on the Nelson River. Sampling locations include the Burntwood River, Nelson River, Grass River and Stephens Lake. The objectives were to examine lake sturgeon biology, identify spawning areas, determine abundance and habitat use, monitor movements and to determine if lake sturgeon ascend Birthday Rapids and/or Gull Rapids. Gillnets and larval drift nets were used to sample lake sturgeon and eggs and larvae. Radio and acoustic transmitters were used to monitor movements. A total of 139 lake sturgeon were captured, 79 from the Nelson River, 23 from the Burntwood River, 13 in the Nelson and Grass Rivers and 24 in Stephens Lake. Spawning areas, seasonal habitat use and habitat characteristics were described.

Bartley, D., Gall, G.A.E., and Bentley, B. 1983. A description of the genetic structure of lake sturgeon from the Menominee River, Wisconsin. Wis. Dept. Nat. Res. MS. Rep. 10 p.

The genetic characteristics of two sub-populations of lake sturgeon from the Menominee River, isolated from each other by the Grand Rapids dam, were described using starch gel electrophoresis and 12 enzyme systems from muscle tissue. Of the 24 loci surveyed, nine were found to be polymorphic

and the average heterozygosities were 0.12, 0.10 and 0.11 for White Rapid, Grand Rapid and total areas, respectively. G_{ST} was estimated to be 0.026, indicating that the two populations had not diverged very far and that the greatest source of genetic variation was due to differences among individuals within each subpopulation.

Bassett, C. 1982. Management plan for lake sturgeon (*Acipenser fulvescens*) in the Indian River and Indian Lake, Alger and Schoolcraft counties, Michigan. United States Forest Service, Manistique Ranger District, Hiawatha National Forest in cooperation with Michigan Department of Natural Resources, Manistique, Michigan. Pagination unknown.

This document was not available for annotating.

Beamesderfer, R.C.F., and Farr, R.A. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Environ. Biol. Fishes 48: 407-417.

This paper provided a review of the life history and habitat requirements of sturgeon. The authors also discussed alternatives for their protection and restoration in North America, and a protection and enhancement program in the Columbia River. A discussion of protective measures and rehabilitation practices was provided in light of a survey of sturgeon biologists and managers in North America. It appeared that restrictions and aquaculture stocking programs would be implemented instead of the use of a system-wide approach needed to affect sturgeon habitat.

Beamish, F.W.H., Jebbink, J., Rossiter, A., and Noakes, D.L.G. 1996. Growth strategy of juvenile lake sturgeon (*Acipenser fulvescens*) in a northern river. Can. J. Fish. Aquat. Sci. 53: 481-489.

Lake sturgeon seasonal and size-related changes in proximate composition and energy were studied in a population in the northern region of the species' geographical distribution. Condition factor, whole body and muscle water, protein, lipid, inorganic, and energy contents increased with total length. Condition factor did not vary among seasons. Proximate component and energy content for sturgeon of a given size did not vary between June and October but were different in March. Lipid and protein contents

varied inversely with water when they were expressed as a percentage of whole body weight. The hepatosomatic index decreased with total length and did not differ between June and October, but March values were lower. The relative water, protein, and inorganic content of the liver decreased, and lipid and energy content increased, with total length. The relative lipid and energy contents of liver were also lowest in March, but the lipid content was highest in July. The opposite was found for protein and water content.

Beamish, F.W.H., Noakes, D.L.G., and Rossiter, A. 1998. Feeding ecology of juvenile lake sturgeon, *Acipenser fulvescens*, in northern Ontario. *Can. Field Nat.* **112**: 459-468.

The stomach contents of lake sturgeon from a source-poor habitat were analyzed to determine their diet. Cladocera were numerically the most abundant, but were only found in four specimens. Mayfly larvae (primarily Hexagenia) were the next most abundant (34% of all prey) and taken by 75% of all sturgeon. Other common prey items were Odonata, Annelida, Mollusca, Diptera, and Trichoptera, each composing 5% to 8% of all prey items. There was no dietary partitioning within the range of juvenile sturgeon or between other fish species such as suckers, lake whitefish, and burbot, suggesting severe competition for food. The low food abundance was reflected in the slow growth rate of sturgeon in the study area. If there was a further depletion in food resources, there would be significant implications for their growth and survival.

Bean, T.H. 1903. Order Chondroistei, sturgeons, p. 63-69. *In* Catalogue of the fishes of New York. N.Y. State Mus. Bull. **60**.

The lake sturgeon appeared under the name *Acipenser rubicundus* Le Sueur, with *A. maculosus* Gunther as the sole synonym. The review by Kirsch and Fordice (1889, see in this bibliography) on the North American acipenserids was not referred to. The description was followed by brief notes on size and habits. Several species of snails, and occasionally fish eggs, served as food items. The parasitic lamprey eel (*Petromyzon concolor*) apparently caused ulcerous sores.

Beaulieu, G., and Corbeil, E. 1964. Étude préliminaire de l'esturgeon de lac, *Acipenser fulvescens*, dans la région de l'Abitibi. *Nat. Can. (Qué.)* **91**: 175-181.

This was a study of lake sturgeon in the Abitibi region, including Lake Waswanipi, during 1961. Two hundred and fourteen sturgeon were captured and tagged and of these 29 were recaptured. Based on captures, the younger sturgeon appeared to tolerate higher temperatures than older sturgeon. The greatest distance moved was 48 km over a period of three days.

Begnoche, L.J., Quintal, R.T., Chernyak, S.M., and Hickey, J.P. 2003. Survey of chlorinated and brominated organic contaminants in Great Lakes lake sturgeon, p. 247. *In* International Association for Great Lakes Research 46th Annual Conference & International Lake Environment Committee 10th World Lakes Conference. Global Threats to Large Lakes: Managing in an Environment of Instability and Unpredictability. June 22-26, 2003. DePaul University, Chicago, Illinois. [Abstract only].

Behning, A. 1913. Freilebendes *Polypodium hydriforme* Uss. in der Wolga bei Saratow. *Zool. Anz.* **41**: 172-173.

Free-living polyps of *Polypodium* were found near Saratow, in a side arm of the stream Tschapowka. The single specimen of a free-living polyp of *Polypodium* was collected from seven meter deep waters along with a few specimens of *Hydra*. The *Polypodium* had twelve tentacles.

Bemis, W.E., and Findeis, E.K. 1994. The sturgeons' plight. *Nature* **370**: 602.

The authors stated that all species of sturgeon faced the possibility of extinction because of overexploitation, pollution, habitat destruction, and barriers to spawning grounds caused by hydroelectric structures. The nature of the life cycle of sturgeon and their dependence on large river systems were cited as two of the main reasons why the species is vulnerable. Discussion of sturgeon at the taxonomic level generated some discrepancies.

Bemis, W.E., and Kynard, B. 1997. Sturgeon rivers: an introduction to acipenseriform biogeography and life history. *Environ. Biol. Fishes* **48**: 167-183.

The authors examined the biogeography of sturgeon and suggested that they originated in Europe and diversified in Asia. Acipenseriformes did not share a common life history. There was significant variation within and between species. They argued that the present level of knowledge on these unique fish did not allow conclusions to be drawn on whether anadromy or potamodromy was the pleisomorphic life history pattern for acipenseriformes. Rivers were proposed as the central unit for examining living sturgeon biogeography. Nine biogeographic provinces were recognized. Interestingly, *Acipenser ruthenus* spanned three of the nine provinces and appeared to have different life histories in different river systems.

Bemis, W.E., Birstein, V.J., and Waldman, J.R. 1997. Sturgeon biodiversity and conservation: an introduction. *Environ. Biol. Fishes* **48**: 13-14.

This article introduced the volume of *Environmental Biology of Fishes* containing many of the papers presented at the International Conference on Sturgeon Biodiversity and Conservation, held at The American Museum of Natural History, New York, from the 28 to 30 July, 1994. A summary of the volume is given as well as a brief discussion of the naming conventions used.

Bemis, W.E., Findeis, E.K., and Grande, L. 1997. An overview of acipenseriformes. *Environ. Biol. Fishes* **48**: 25-71.

The authors constructed relationships amongst acipenseriformes based on comparative osteology. The taxa highlighted include *Cheirolepis*, *Polypterus*, *Mimia*, *Moxythomasia*, *Bigeria*, *Saurichthys*, *Lepisosteus*, and *Amia*. Genetic diversity was examined within the families of recent acipenseriformes (Chondrosteidae, Peipiaosteidae, Polodontidae, and Acipenseridae) and a cladogram describing the osteological characteristics was provided. Monophyly of the two extant families was supported, but needed further analysis. Five characteristics crucial to the biology of acipenseriformes found from this study included

specializations of jaws and operculum relevant to jaw protrusion, feeding and ram ventilation, anadromy or potamodromy and demersal spawning, paedomorphosis and evolution of the group, the biogeography of Asian and North American polyodontids and scaphirhynchines, and the high number of electroreceptive organs in the rostral and opercular regions. Nomenclatural suggestions were summarized.

Benson, A., Sutton, T., Elliott, R., Meronek, T., and Bacula, T. 2004. Movement and habitat use of juvenile lake sturgeon in the Peshtigo River, Wisconsin. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Radio transmitters were attached to fish greater than 75 g. Water quality, depth, and velocity were measured. Benthic samples were collected to be analyzed for macroinvertebrate assemblages. Sturgeon had an average fork length of 23 mm and an average weight of 83 g. All fish were found over sand substrates dominated by Chironomidae at an average depth of 0.56 m and an average velocity of 0.33 m/sec. This environment characterizes ideal nursery habitat. Juvenile sturgeon showed variable movement in the river and moved into Green Bay when temperatures decreased.

Benson, A., Sutton, T., Elliott, R., Meronek, T., and Gunderman, B. 2004. Evaluation of sampling techniques for juvenile lake sturgeon in the Peshtigo River and Green Bay, Wisconsin. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The objective of this study was to determine the most efficient gear type for catching juvenile lake sturgeon. Techniques used included wading surveys with dip nets, haul seines, backpack electrofishing, snorkelling, set lines, bottom trawls, gill nets, and fyke nets. Catch-per-unit-effort (CPUE) was highest for night wading surveys (CPUE = 1.99 fish/hr), followed by day wading surveys and day seining (CPUE = 1.62 and 1.23 fish/hr, respectively). No sturgeon were caught when bottom trawls or fyke nets were used. Night wading was recommended as the best technique for capturing juvenile lake sturgeon in shallow water with low turbidity.

Benson, A.C., Sutton, T.M., Elliott, R.F., and Meronek, T.G. 2005. Seasonal movement patterns and habitat preferences of age-0 lake sturgeon in the lower Peshtigo River, Wisconsin. *Trans. Am. Fish. Soc.* **134**: 1400-1409.

This study was conducted to determine habitat preferences and movement patterns of age-0 lake sturgeon in the Lower Peshtigo River, Wisconsin. Water depth, velocity, temperature, substrate type and macroinvertebrate assemblage were determined at each catch site. The water depth was always less than 2 metres, the substrate was sand, the velocity was less than 0.6 m/s and the dominant macroinvertebrates were Dipteran larvae. The median macroinvertebrate density was lower at catch sites than in the rest of the study area. Monitoring of movements by radio transmitters indicated greater activity after dark and seasonal patterns related to changes in water temperature.

Berg, L.S. 1948. *Acipenseriformes*, p. 57-111. In *Freshwater fishes of the USSR and adjacent countries*. Volume 1. Izdatel'stvo Akademii Nauk SSSR; Israel Program for Scientific Translations Catalog **74**, Moscow - Leningrad.

This book contained information on acipenserids not covered in any other work (*Huso dauricus* and the three species of *Pseudoscaphirhynchus*).

Bergstedt, R., Scholefield, R., and Swink, W. 2003. Annual report of the Hammond Bay Biological Station to the Great Lakes Fishery Commission for the period June 2002 through May 2003. United States Fish and Wildlife Service, Sea Lamprey Control. 3 p.

This document was not available for annotating.

Berkes, F. 1979. An investigation of Cree Indian domestic fisheries in northern Québec. *Arctic* **32**: 46-70.

Data for this study were collected by sampling the catch of Cree fishers, mainly in Fort George. Lake sturgeon were not caught in the domestic fishery between 1975 and 1977. Overall, sturgeon made up less than 0.1% of the domestic catch in the Fort George area and 1.5% of the catch in inland lakes (Mistassini, Waswanipi and Nemaska traplines).

Berkes, F., and Mackenzie, M. 1978. Cree fish names from eastern James Bay, Québec. *Arctic* **31**: 489-195.

This paper provided names of fishes in the languages of the Cree communities of the eastern James Bay area. The lake sturgeon was known as "nimaw" in the dialect of the Fort George and Wemindji communities, and "namew" by the Eastmain, Rupert House, Waswanipi, Nemaska and Mistassini communities.

Berkes, F., George, P., Preston, R., Turner, J., Hughes, A., Cummins, B., and Haugh, A. 1992. Wildlife harvests in the Mushkegowuk Region. Research Program for Technology and Assessment in Subarctic Ontario, McMaster University, Hamilton. TASO Report, Second Series **6**: iii + 68 p. + apps.

A questionnaire study was conducted to determine harvests of fish and wildlife by the aboriginal people of Moose Factory, Moosonee, New Post, Fort Albany, Attawapiskat, Kashechewan, Peawanuck and Fort Severn in 1990. Nine hundred and twenty-five men over the age of 18 were interviewed for 56% coverage in a stratified sampling design. A total of 4,768 lake sturgeon were reported caught; 2,775 in Moose Factory, 399 in Moosonee, 68 in Fort Albany, 300 in Kashechewan, 1,223 in Attawapiskat, and 3 in Peawanuck. The Attawapiskat study did not differentiate between species so the total was divided up to be in the same proportions as Kashechewan. The average edible weight of lake sturgeon is given as 5.68 kg per sturgeon. This resulted in a total of 27,079.4 kg for all communities; 15,762.0 kg for Moose Factory, 2,266.3 kg for Moosonee, 386.2 kg for Fort Albany, 1,704.0 kg for Kashechewan, 6,943.8 kg for Attawapiskat and 17.0 kg for Peawanuck. The replacement value for all fish harvested by all communities was calculated to be \$1,724,633.

Berkes, F., George, P.J., Preston, R.J., Hughes, A., Turner, J., and Cummins, B.D. 1994. Wildlife harvesting and sustainable regional native economy in the Hudson and James Bay Lowland, Ontario. *Arctic* **47**: 350-360.

A total of 925 interviews were conducted on aboriginal residents of Moose Factory, Moosonee, New Post, Fort Albany,

Kashechewan, Attawapiskat, Peawanuck and Fort Severn. This gave 56% coverage in a stratified sampling design. A total of 3,850 sturgeon were reported harvested by all communities. This gave a projected harvest of 4,768. The average edible raw weight per sturgeon was given as 5.68 kg. The potential edible weight for all fish in all communities was calculated to be 133,872 kg with a replacement value of \$1,724,633 in 1990 dollars. Values are also presented by community.

Bernatchez, L., and Saint-Laurent, R. 2004. Centrale de l'Estmain-1-A et dérivation Rupert. Caractérisation génétique de l'esturgeon jaune et de l'omble de fontaine. Report submitted by Université Laval to Société d'énergie de la Baie James, agent for Hydro-Québec Production. 37 p. + apps. Available from <http://www.bip-pio.qc.ca/en/docu.asp> [accessed 30 March 2006].

The genetic characterization of lake sturgeon and brook trout from the Rupert River watershed was undertaken as part of an environmental impact assessment. Lake sturgeon allele frequencies were analyzed in adult fish before the spawning period in the upper and lower Rupert River to determine population structuring. Genetic isolation of lake sturgeon among different watersheds was also examined. Results demonstrated distinct populations of lake sturgeon between Eastmain-Opinaca watersheds and Rupert River. No genetic structuring was evident within the Eastmain-Opinaca system although three distinct populations were present in the Rupert River. Results from microsatellite analysis of Rupert River brook trout indicated that the majority of fish sampled had a similar genotype to the giant trout found within the river.

Bernatchez, L., and Wilson, C.C. 1998. Comparative phylogeography of Nearctic and Palearctic fishes. *Molecular Ecology* 7: 431-452.

The lake sturgeon was one of a group of 42 species analyzed for the impact of historical events on evolutionary patterns and processes. The analysis was conducted by combining phylogeographic data from mitochondrial DNA of the various species. The median latitudinal range used for lake sturgeon was 46. Other factors used include overall nucleon diversity (0.43), maximum intraspecific sequence divergence (0.0074), nucleotide diversity index

(0.0032), and evolutionary female effective population size (8×10^3). Similar phylogeographic patterns were found among southern species. Regression analysis showed significant latitudinal shifts in intraspecific genetic diversity. Evolutionary dispersal rates differed by two orders of magnitude between species from glaciated and nonglaciated regions. The implications of this approach to conservation programs are discussed.

Bernhardt, W.J., Baker, R.F., and Graveline, P.G. 1992. A fisheries survey of the Nelson River mainstem near Angling River 1991. North/South Consultants Inc., Winnipeg, Manitoba. vi + 30 p.

Differences in seasonal abundance of fish species in the Nelson River mainstem were determined from a gillnetting study conducted in 1991. A total of 731 fish were captured. Species composition was similar from one season to the next, but relative abundance was different between spring and fall surveys. Lake sturgeon ranged from 11 to 31 years of age, with the majority being 13 to 18 years old. None of the sturgeon appeared to be sexually mature, suggesting that sturgeon may not spawn in that area of the Angling River. However, sturgeon were sexually active for a short period of time and could have spawned prior to the first capture in June 18. Lake sturgeon made up 7.1% of the spring gillnet catch, and 1.1% of the fall gillnet catch in the lower Nelson River mainstem. They comprised 4.1% of the total population.

Berril, N.J. 1950. Development and medusa bud formation in Hydromedusae. *Q. Rev. Biol.* 25: 292-316.

Development and budding were described in 4 orders of the Hydromedusae. The section on Narcomedusae contained a review of the developmental cycle of *Polypodium hydriforme*. Lipin's work of 1911 and 1926 was reviewed, along with figures. The parasitic stolon lay coiled within the acipenserid eggs and had an everted structure so that the endodermis was external and in contact with the yolk. Buds formed on the stolon and twelve tentacles developed subsequently on each bud. When the sturgeon eggs were laid, stolons exited the eggs and formed free living polyps with 12 to 24 tentacles that developed saccular gonads. The polyp

stage may itself be a medusa, and a better developed medusa may not exist for this organism.

Berry, D.K. 1996a. Alberta's lake sturgeon management plan. Alberta Environmental Protection, Natural Resources Service, Fisheries Management Division. vii + 20 p.

The lake sturgeon of Alberta and management plans to provide recreational sturgeon fishing opportunities through conservation were discussed. There are two populations of lake sturgeon in Alberta - one in the North Saskatchewan River and one in the South Saskatchewan River. The populations have still not fully recovered from overfishing prior to the 1940s. New sport fishing regulations were developed based on an angler survey and sturgeon population status in the province. Beginning in 1997, a sturgeon fishing license would only be valid for keeping one sturgeon over 130 cm in total length from the South Saskatchewan River from June 16 to March 31. Fishing for sturgeon during spawning periods would only be on a catch and release basis.

Berry, D.K. 1996b. Angler opinion survey on sturgeon management in Alberta. Alberta Environment Protection, Fisheries Management Division, Edmonton, AB. 4 p. + app.

This document summarized angler responses to a survey of their opinions on the management and regulation of sturgeon in Alberta. Sturgeon population management plans were strongly supported. Most anglers were interested in sturgeon that were larger, as shown by their support for a minimum size limit. Most anglers also supported a harvest limit of zero or one fish annually. Differences in opinions of anglers fishing the North and South Saskatchewan rivers were discussed. The actual survey and a response summary were appended.

Berst, A.H., and Spangler, G.R. 1973. Lake Huron: the ecology of the community and man's effects on it. Gr. Lakes Fish. Comm. Tech. Rep. No. 21: iv + 43 p. Available from www.glfc.org/pubs/TechReports/Tr21.pdf [accessed 30 March 2006].

Instability of the commercial fishery resources of Lake Huron has occurred since the 1940s. The dynamics of different aspects of fishery resources in Lake Huron were described. Lake

sturgeon harvest declined from 250 metric tonnes in 1889 to insignificant levels in 1909. Overexploitation was cited as the main cause of the near extirpation of lake sturgeon in Lake Huron.

Bigrigg, J.U., Binkowski, F.P., and Bruch, R. 2003. Food habit study of lake sturgeon, *Acipenser fulvescens*. In 2003 Annual meeting of the American Society of Limnology and Oceanography, Salt Lake City, UT, 8-14 February, 2003. The Earth's eyes: aquatic sciences through space and time. Pagination unknown. [Abstract only]. Available from <http://www.sgmeet.com/aslo/slc2003/viewabstract.asp?AbstractID=382&SessionID=SS3.21> [accessed 30 March 2006].

Bills, T. Boogaard, M., and Gaiowski, M. Date unknown. Avoidance behavior of juvenile lake sturgeon (*Acipenser fulvescens*) exposed to the Bayluscide 3.2% granular sea lamprey larvicide, Bayluscide 70% WP, TFM, and a TFM 1% Bayluscide 70% WP mixture. United States Fish and Wildlife Service, Sea Lamprey Control. 20 p.

This document was not available for annotating.

Binkowski, F.P. 1987. Feeding behaviour of young lake sturgeon as a function of olfactory response. In Program and Abstracts, 11th Annual Larval Fish Conference. Gr. Lakes Fish. Comm., Mich. Dept. Nat. Res. Pagination unknown. [Abstract only].

This was presented at the annual larval fish conference held at Michigan Technological University, Houghton, MI, in 1987 as part of the special session "North American Sturgeon Larvae". The published proceedings did not contain this article. Interested readers are directed to the Michigan DNR for a copy.

Binkowski, F.P. 1997. Artificial propagation of lake sturgeon: A 100 year review, p. 21. In Abstracts: A-K, 127th Annual Meeting of the American Fisheries Society, 24-28 August 1997, Monterey, California. Fisheries at Interfaces: Habitats, Disciplines, Cultures. [Abstract only].

Binkowski, F.P., and Bruch, R.M. 2004. Post stocking behavior of lake sturgeon. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, WI. Pagination unknown. [Abstract only].

Fingerlings, yearlings, and subadult lake sturgeon from the upper Fox and Wolf rivers were pit tagged 30-60 days prior to release in order to study post-stocking activities. A total of 53 fingerlings and yearlings were implanted with radio transmitters. Nine subadults were fitted with external tags. Tag life for fingerlings was 20-30 days, 160-200 days for yearlings, and 700 days for subadults. For the first 5 days radio tracking was conducted for 8-20 hours/day with subsequent tracking being conducted by airplane bi-weekly. The primary response was rapid dispersal and movement downstream for stocking conducted in June and August. Following stocking in November and December all age groups showed a slow distribution and limited movement downstream. After one year, 70% of the subadults were still in the river system, where they overwintered in holes 15-25 feet deep.

Binkowski, F.P., and Czeskleba, D.G. 1980. Methods and techniques for collecting and culturing lake sturgeon eggs and larvae. Wisconsin Dept. Nat. Res., Madison. MS Rep. 2 p.

This brief note described the methods used to collect sperm and eggs from ripe lake sturgeon. Eggs were collected by conventional stripping and by caesarean sectioning. Sperm were collected with the help of a syringe. No difference in fertilization was observed between freshly collected sperm and sperm stored on ice for two hours. Water temperatures ranged from 14-16°C; bentonite clay was used in suspension after fertilization and during water hardening of eggs. Eggs were incubated in quart hatching jars and 84% of the eggs hatched in 7 days. Approximately 300,000 two-day old sac-fry were stocked in the Red Cedar River and 24,000 were held at the Wild Rose State hatchery. The rest were held at the Centre for Great Lakes Studies, University of Wisconsin-Milwaukee, and fed a diet of W-13 formulated dry food, tetramin, and fresh frozen zooplankton. At the hatchery, the diet consisted of W-7 and W-13 formulated dry foods, supplemented by beef liver and live brine shrimp nauplii. Increased water temperatures of 19°C during the sac fry stage and 22°C during the exogenous feeding stage (at the hatchery) resulted in faster growing fish. At 5 months, the university reared sturgeon were 50-150 mm, whereas the hatchery reared sturgeon reached 80-230 mm.

Birstein, V.J. 1993. Sturgeons and paddlefishes: threatened fishes in need of conservation. *Conserv. Biol.* 7: 773-787.

This article reviewed endangered and threatened sturgeon and paddlefish species. Three species from the then Soviet Union were the most endangered, particularly the Amu-Dar shovelnose, *Pseudoscaphirhynchus kaufmanni*. The author called on scientists from all nations to set an international goal of conservation because the effort could not be made by Russian scientists alone.

Birstein, V., and Bemis, W. (ed.) 1993-1996. The sturgeon quarterly. American Museum of Natural History. 1-4. [Newsletter series]

Summaries and abstracts of research being conducted and published on sturgeon were provided.

Birstein, V., and Waldman, J. (ed.) 1996-1997. The Sturgeon Quarterly. American Museum of Natural History. 4-5. [Newsletter series].

Summaries and abstracts of research being conducted and published on sturgeon were provided.

Birstein, V.J., and Bemis, W.E. 1997a. How many species are there within the genus *Acipenser*? *Environ. Biol. Fishes* 48: 157-163.

Problems surrounding *Acipenser* taxonomy were addressed, in particular the number of species that should be recognized, and what their scientific names should be.

Birstein, V.J., and Bemis, W.E. 1997b. Leo Semenovich Berg and the biology of acipenseriformes: a dedication. *Environ. Biol. Fishes* 48: 15-22.

This article was dedicated to the Russian ichthyologist and geographer Leo Semenovich Berg (1876-1950). It described his life, accomplishments, and scientific research on acipenseriforms.

Birstein, V.J., Poletaev, A.I., and Goncharov, B.F. 1993. DNA content in Eurasian sturgeon species determined by flow cytometry. *Cytometry* 14: 377-383.

This article dealt mainly with Eurasian sturgeon species. The lake sturgeon was mentioned briefly on page 382 as being octoploid.

Birstein, V.J., Bemis, W.E., and Waldman, J.R. 1997. The threatened status of acipenseriform species: a summary. *Environ. Biol. Fishes* **48**: 427-435.

The authors discussed the plight of acipenseriformes on a global scale. The lake sturgeon was listed as threatened in Canada and the USA according to national listings, and vulnerable in Canada and the USA according to IUCN listings in 1994 and 1996.

Birstein, V.J., Hanner, R., and DeSalle, R. 1997. Phylogeny of the acipenseriformes: cytogenetic and molecular approaches. *Environ. Biol. Fishes* **48**: 127-155.

The authors outlined a phylogeny based on molecular analysis. Within the genus *Acipenser*, polyploidization was one of the main genetic mechanisms of speciation by which 8n and 16n-ploid species were formed. Individual gene trees were constructed for sequenced partial fragments. There were two departures from current trends in morphological studies. *Huso dauricus* was a sister-species to *Acipenser*. In addition, *Scaphirhynchus* and *Pseudoscaphirhynchus* did not comprise a monophyletic group. The phylogenetic tree of cytochrome *b* gene fragments showed that octoploid species appeared at least three times within *Acipenser*.

Bishop, F.G. 1981. The 1980 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 18 p.

Two hundred and sixty seven anglers purchased a lake sturgeon fishing license (1980/81) and of these 82% returned the questionnaires mailed to them. Seventy-six percent fished for sturgeon and 34% of the respondents caught a sturgeon. The estimated catch in 1980 was 74 sturgeon, the highest harvest since 1968. The largest sturgeon caught was 62 pounds and the average weight was 15 pounds (6.8 kg); close to the historical average of 15.2. Recommendations included no changes in current legislation, an annual assessment of the population, no increase in the size limit, steps should be taken to reduce the nutrient loads in

the South Saskatchewan River, and an effort should be made to obtain information on catch per unit effort in the sport fishery.

Bishop, F.G. 1982. The 1981 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. v + 18 p.

A total of 408 anglers (72% of total) who purchased a sturgeon angling license returned questionnaires. Seventy-seven percent fished for sturgeon and 43% caught at least one sturgeon. The extrapolated total catch was 150 sturgeon and the estimated exploitation rate was 5.2%. The largest sturgeon caught weighed 105 pounds and was a new record for Alberta. The average weight was 14 pounds, close to the historical average of 15.2 pounds. Most of the sturgeon caught were from the Grand Forks area. Recommendations included: no changes to current legislation the gathering of more information on sturgeon biology, survey subsampling of anglers to save time and money, and the modification of questionnaires to include catch per unit effort.

Bishop, F.G. 1983. The 1982 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. iv + 26 p.

This was a continuation of the annual reports on lake sturgeon in Alberta based on questionnaires. Five hundred and fifty two anglers purchased licenses and 79% returned the questionnaires. A total of 611 sturgeon were caught, of which 486 were released. The harvest estimate was 181. Some respondents suggested increased enforcement patrols. The average weight of sturgeon caught was 13 pounds or 6.3 kg. Rattlesnake Hole of the South Saskatchewan was the best area to catch sturgeon (0.124 fish/hr). The best bait was a combination of fish and meat. The population was considered healthy and no changes in the regulations were considered necessary.

Bishop, F.G. 1984. The 1983 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River in Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. v + 20 p.

This was an annual report and estimate of harvest based on questionnaires. Questionnaires were mailed to the 536 license

holders and 79% of the questionnaires were returned. Thirty eight percent of respondents caught at least one sturgeon. The total catch was 555 of which 83% were released and the estimated harvest was 120 sturgeon. The largest sturgeon caught was 101 pounds and the average weight was 15 pounds (6.8 kg). Catch per unit effort showed that Rattlesnake Hole was the best place to catch sturgeon (0.16 fish/hr). A combination of native minnows, meat, and worms were considered to be the best bait. The average time spent fishing was 5.2 days.

Bishop, F.G. 1985. The 1984 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 19 p.

A total of 392 licenses were issued (a marked decline from previous years). Questionnaires were sent to license holders and 79% were returned. Forty one percent of respondents caught at least one sturgeon. The total catch was 431 of which 88% were released and the estimated harvest was 67 fish. The average weight of sturgeon caught was 12 pounds (5.4 kg).

Bishop, F.G. 1986. The 1985 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 16 p.

Three hundred and twelve licenses were purchased. Questionnaires were sent to license holders and 72% were returned. Thirty-five percent of the respondents caught at least one sturgeon. The total catch reported was 80 sturgeon, of which 72% were released. Harvest was estimated at 25 fish with an average weight of 15.8 pounds (7.2 kg).

Bishop, F.G. 1987. The 1986 harvest of lake sturgeon from the various rivers in Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 18 p.

Three hundred and forty nine licenses were purchased. Questionnaires were sent to license holders and 81% were returned. Forty one percent of respondents caught at least one sturgeon. A total of 455 sturgeon were caught, of which 82% were released. The estimated harvest was 102 sturgeon. Most of the sturgeon caught came from the South Saskatchewan River. Thirty-six were caught in the Old Man

River, six in the Red Deer River, and 12 in the North Saskatchewan River. The average weight of sturgeon caught was 15.2 pounds (6.9 kg). Eight tagged sturgeon were caught and catch per unit effort (0.11 fish/hr) was up over the previous year.

Bishop, F.G. 1988. The 1987 harvest of lake sturgeon in various rivers in Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 17 p.

Three hundred and ninety seven sturgeon angling licenses were purchased and the holders were sent questionnaires. Eighty-one percent of the questionnaires were returned. Seventy-three percent of the respondents fished, and 41% caught at least one sturgeon. A total of 731 sturgeon were caught, of which 91% were returned. The estimated harvest was 82 sturgeon. Most sturgeon were caught in the South Saskatchewan River. A total of 14 were caught in the Red Deer River and 3 in the North Saskatchewan River. The average reported weight was 6 pounds (2.7 kg), a substantial decrease from the historical average of 14.6 pounds (6.6 kg). Three tagged fish were caught by anglers.

Bishop, F.G. 1989. The 1988 harvest of lake sturgeon from various rivers in Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 17 p. + apps.

This report discussed the 1988 results of an ongoing study on lake sturgeon harvests in Alberta. Questionnaires were sent to anglers who purchased a sturgeon license. A total of 253 licenses were sold and 194 completed questionnaires were returned. Seventy-eight percent of respondents actually fished for sturgeon, and 46% caught at least one sturgeon. A total of 441 sturgeon were caught in 1988, with 398 (90%) of them being released. The 1988 size distribution is tabulated. The mean weight of sturgeon caught in 1988 was 6 lbs; the largest was a 78 lb sturgeon caught at Sandy Point. The majority of sturgeon were caught in the South Saskatchewan River. Ninety-seven percent of respondents fished the South Saskatchewan River, 2% fished the North Saskatchewan River, 0.5% fished the Red Deer River, and 0.5% fished the Oldman River. The best angling success occurred at the Rattlesnake Hole on the South Saskatchewan River (average of 1 sturgeon caught for every 6

hours fished). The lowest level of success in the South Saskatchewan River was found at the Grand Forks (average of 1 sturgeon caught for every 100 hours fished). The 1988 results were compared to those from previous years.

Bishop, F.G. 1990. The 1989 harvest of lake sturgeon from various rivers in Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 18 p. + apps.

A total of 305 anglers purchased an angling license in the 1989-1990 season. Of 239 questionnaire respondents, 68% caught a total of 519 sturgeons. The majority (473 or 91%) were released. The mean weight of the sturgeon caught (14.1 lbs) equalled the long term average. Most of the angling occurred on the South Saskatchewan River (87%) followed by the North Saskatchewan River (8%), Red Deer River (3%) and Oldman River (2%).

Bishop, F.G. 1992. The 1990 harvest of lake sturgeon in Alberta. Alberta Forestry, Lands and Wildlife, Fish and Wildl. Div. MS Rep. vi + 19 p.

Questionnaires were sent to anglers who purchased a sturgeon license in 1990. A total of 265 licenses were sold and 175 (66%) completed questionnaires were returned. Seventy-four percent of anglers actually fished for sturgeon and 49% caught at least one sturgeon. A total of 559 sturgeon were caught in 1990, with 513 (92%) being released. The mean weight of sturgeon caught in 1990 was 16 lbs; the largest was a 64 lb (estimated from length) sturgeon caught in the Rattlesnake Hole area. A 60 lb sturgeon was also caught in the North Saskatchewan River at the Genesee crossing. A total of 89% of respondents fished the South Saskatchewan River, 4% fished the North Saskatchewan River, 4% fished the Oldman River, 2% fished the Red Deer River, and 2% fished the Peace River (does not contain sturgeon). The best angling success occurred at Rattlesnake Hole on the South Saskatchewan River (average of 1 sturgeon caught for every 4.5 hours fished). The lowest angling success on the South Saskatchewan River occurred at the Grand Forks (average of 1 sturgeon caught for every 16.6 hours fished). The 1990 results were compared to those from previous years.

Bishop, F.G. 1993a. The 1991 harvest of lake sturgeon in Alberta. Alberta Environmental Protection, Fish Wildl. Div. MS Rep. 14 p.

In 1991, sturgeon license sales increased by 35% compared to 1990, but only 70% of the license holders actually fished for sturgeon. Of the anglers who fished, 55% caught at least one sturgeon, the highest percent reported since 1968. Of sturgeon licenses, 39% were issued to fisherman for the first time. A total of 765 sturgeon were caught in 1991, with 95 being kept. A total of 722 of the sturgeon caught in Alberta were from the South Saskatchewan River (a 32% increase from 1990). A total of 39 were caught from the North Saskatchewan River (a 1200% increase from 1990). The average weight of the sturgeon was 8.6 kg, with the maximum being 27.2 kg. More effort was expended by sturgeon fisherman in 1991 than in the previous three years. The greater number of catches could have been because the South Saskatchewan River was higher than normal in the latter part of May and June, and most of July and August.

Bishop, F.G. 1993b. The 1992 harvest of lake sturgeon in Alberta. Alberta Environmental Protection, Fish Wildl. Div. MS Rep. 14 p.

Questionnaires were sent to anglers who purchased a sturgeon license in 1992. A total of 327 sturgeon licenses were sold and 227 (70%) completed questionnaires were returned. Seventy-nine percent of anglers actually fished for sturgeon, and 47% caught at least one sturgeon. A total of 963 sturgeon were caught in 1992, and an estimated 124 (9%) of these were kept. The size distribution is tabulated. The average weight of sturgeon caught in 1992 was 7.6 kg, and the largest fish caught weighed 32.7 kg. Most of the sturgeon were caught in the South Saskatchewan River (97%), with the remaining 3% being caught in the North Saskatchewan River. The location with the highest fishing success on the South Saskatchewan River was the Rattlesnake Hole, with an average of 0.459 fish caught per hour. The 1992 results were compared to those from previous years.

Bishop, F.G. 1995. The 1993 harvest of lake sturgeon in Alberta. Alberta Environmental Protection, Fish Wildl. Div. MS Rep. 18 p.

Sturgeon license sales increased by 6% in 1993 from 1992. Only 59% of the individuals fished for sturgeon and of these, 60% caught at least one sturgeon. Approximately 33% of the licenses were issued to first time sturgeon

fishers. A total of 508 sturgeons were caught by respondents, and 59 were kept. Almost all of the sturgeons were caught in the South Saskatchewan River (96%). The rest were caught in the North Saskatchewan and Red Deer rivers.

Bishop, F.G. 1996. The 1994 harvest of lake sturgeon in Alberta. Alberta Environmental Protection, Fish Wildl. Div. MS Rep. 17 p.

Sturgeon fishing license sales increased by 30% from 1993, with 73% of the license holders actually fishing for sturgeon. Of these 50% caught at least one sturgeon. Approximately 33% of these licenses were issued to first time sturgeon fishers. A total of 787 sturgeon were caught, and 79 were kept. The majority of the sturgeon (87%) were caught in the South Saskatchewan River, with the rest being caught in the North Saskatchewan and Oldman rivers. Anglers spent an average of 5.1 days fishing for sturgeon, an increase from the previous year most likely due to normal summer conditions as compared to the wet conditions experienced in 1993.

Blackledge, K.H., and Bidwell, C.A. 1993. Three ploidy levels indicated by genome quantification in acipenseriformes of North America. *J. Hered.* **84**: 427-430.

Genome size in seven of eight North American acipenseriformes was determined using flow cytometry. Genome size ranged from 4.6 to 13.1 picograms. Distinct genome groups occurred in a 1:2:3 ratio showing ploidy differences between groups. Some that had the smallest genomes were considered tetraploids of an ancestral fish (4C). The results of this study supported the theory that intermediate genome size consisted of octaploid (8C) derived species, with dodecaploid being the largest genome (12C). Polyploidization still occurs in Acipenseriformes today, as indicated by spontaneous triploids (3N) of lake sturgeon, and the Gulf of Mexico sturgeon.

Block, D.A. 2001. Growth estimates, habitat use, and ecology of lake sturgeon, *Acipenser fulvescens* Rafinesque, from Round Lake and mature reservoirs in the Winnipeg River. M.Sc. Thesis, University of Manitoba, Winnipeg, MB. x + 171 p. Available from www.collectionscanada.ca/thesescanada/index-e.html [accessed 30 March 2006].

Growth, population estimates, density, and distribution were studied in Round Lake and at Seven Sisters Slave Falls and Slave Falls - Pointe du Bois on the Winnipeg River, Manitoba. Growth rates between the three sites were not significantly different and distributions were related to flow. Movement studies indicated that extensive amounts of time were spent above the bottom, and that movements were related to areas of current. Lake sturgeon preferred fine and medium sand substrates. Ephemeridae were the most abundant food item in the diet of six other fish species in Round Lake. Lake sturgeon also feed on Ephemeridae, so a dietary overlap was assumed.

Blouw, A., Carruthers, B., and Dyck, H. 1994. Communications plan Manitoba Sturgeon Committee. Winnipeg, MB. 5 p. [Draft].

This document presented a plan for increasing public awareness of lake sturgeon. Proposed products included print media, electronic media, a newsletter, a public events display, brochures, a lake sturgeon video, posters, a multimedia computer program, an educational program targeting the Manitoba School Division, and a sturgeon costume for public events.

Boase, J., and Hill, T. 2003. Final report for lake sturgeon spawning in St. Clair River near Port Huron, Michigan. National Fish and Wildlife Foundation Project No. **2001-005-008**: 14 p. + figures, tables. Available from <http://www.fws.gov/midwest/sturgeon/document/s/FinalReport-AdultSturgeonSt.ClairR2002.pdf> [accessed 30 March 2006].

The only known lake sturgeon spawning site in the U.S. waters of Lake Huron is at a natural, deep water reef in the upper St. Clair River. The aim of this study was to determine the origin of the sturgeon that use it, the distribution of adults and their offspring, and spawning habitat characteristics. A total of 47 lake sturgeon were captured. Of these, 3 males and 3 females were implanted with ultrasonic transmitters. Two ripe females collected in commercial trap nets were also implanted. Age and growth data are presented for the 47 sturgeon captured. Substrate images were recorded on video tape and analysed. Telemetry data indicated that at least half of the lake sturgeon came from Lake Huron. Sturgeon also came from downriver locations including Lake Erie, Lake St. Clair and the Detroit River. Underwater structures were an

important feature of the spawning habitat. They provide refuge from the current and were used before and after spawning. The authors suggest that further research be conducted on the importance of refuge areas to sturgeon spawning.

Boase, J., and Manny, B. Date unknown. Lake sturgeon, dinosaur of the Great Lakes. United States Geological Survey. 1 p. [Poster]. Available from http://www.glsc.usgs.gov/_files/research/SturgeonDinosaurPoster.pdf [Accessed 24 September 2006].

Boase, J., Manny, B., Kennedy, G., and Thomas, M. 2004. Final report for lake sturgeon spawning in Lake Huron (MI) - II. National Fish and Wildlife Foundation Project No. 2003-0220-000: 14 p. + figures, tables. Available from <http://www.fws.gov/midwest/sturgeon/document/s/FinalReport-AdultSturgeonSt.ClairR2004.pdf> [accessed 30 March 2006].

The purpose of this study was to capture lake sturgeon spawning at the Port Huron Reef and Sarnia Gravel Dock, implant them with ultrasonic transmitters and track their movements during and after spawning. Forty-seven lake sturgeon were captured in 2002, 55 in 2003 and 18 in 2004. In 2002, 3 females, 3 males and 2 additional sturgeon caught in commercial trap nets were implanted. In 2004, 4 females and 2 males were implanted. No sturgeon were captured at the Sarnia Gravel Dock. Age and growth data from 120 lake sturgeon are presented. Ten of the implanted lake sturgeon likely came from Lake Huron. Shipwrecks and other large debris were used as refuge before and after peak spawning temperatures, and there was a reduced water flow at the spawning site.

Boase, J., Manny, B., Kennedy, G., and Thomas, M. 2005. Final report for evaluation of juvenile lake sturgeon (MI). National Fish and Wildlife Foundation Project No. 2003-0117-004: 12 p. + figures, tables. Available from <http://www.fws.gov/midwest/sturgeon/document/s/FinalReport-JuvenileSturgeonSt.ClairR2004.pdf> [accessed 30 March 2006].

The purpose of this study was to describe lake sturgeon movements within the St. Clair River and to determine the types of habitat used. A

total of 159 lake sturgeon were caught. Of these, 5 were implanted with ultrasonic transmitters, as were 3 from southern Lake Huron. Juvenile lake sturgeon selected habitats in the deepest parts of the North Channel of the St. Clair River. When they were adjacent to deep areas, the sturgeon were over a sand substrate, and in the deep areas they were over an embedded coarse gravel substrate. The availability of spawning habitat may explain why juvenile lake sturgeon are abundant in the North Channel of the St. Clair River, which is an important nursery area.

Boase, J., Thomas, M., Haas, R., Mohr, L., Caswell, N., and Kowalski, A. 2004. Movements of lake sturgeon in the Huron/Erie Corridor. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

In 1994 a tagging and telemetry program was initiated to address management concerns and movement patterns of fish captured in Lake Huron through western Lake Erie. In total, 1,967 lake sturgeon were caught, tagged, and released, with 97 being recaptured. Tag recoveries documented movement patterns within and between systems. Telemetry studies from 1997-2000 (North Channel St. Clair River), 2000-2001 (Detroit River), and 2002-2004 (headwaters St. Clair River) recorded spawning lake sturgeon activities in the only known spawning areas found in the Huron/Erie corridor. Lake sturgeon were found in highest densities in a small area of Lake St. Clair.

Bogatu, D. 1961. Un caz de infestatie cu *Polypodium hydriforme* Ussov, 1885, La cega (*Acipenser ruthenus* L.) din Dunare. Bul. Cercet. Piscic. 20: 54-59.

This was the first case of *Polypodium* in Romanian waters. A female *Acipenser ruthenus*, 5 years old and 29.5 cm long, caught in the Danube River, close to Piscia, was found to be heavily infected with *P. hydriforme*. The infected eggs were twice the diameter of the normal ones and mottled in appearance. On breaking open an infected egg, a 13 mm long stolon with polyps, was released. Control measures suggested for this parasite included intensive fishing in contaminated areas and insuring that infected eggs collected during commercial fishing were not thrown back into the water. (Abstract by Dr. G. Lubinsky, 1976).

Bolker, J.A. 1994a. Comparison of gastrulation in frogs and fish. *Amer. Zool.* **34**: 313-322.

Gastrulation mechanisms were compared between sturgeon and *Xenopus*. In addition, morphogenesis of the dorsal mesoderm in five species of anurans was compared. Phylogenetic analysis made it possible to pinpoint radical from related groups. Teleost gastrulation appeared to have little in common with the ancestral process, and may have evolved as a result of loss of bottle cells in the surface layer and changes in the yolk. The phylogenetic distribution of developmental characters formed the basis for ideas about the origins of major evolutionary changes in development.

Bolker, J.A. 1994b. Embryonic development in the white sturgeon, *Acipenser transmontanus*, p. 10. In *The International Conference on Sturgeon Biodiversity and Conservation*. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Boogaard, M., Bills, T., and Johnson, D. 2003. Acute toxicity of TFM and a TFM/Niclosamide mixture to selected species of fish, including lake sturgeon (*Acipenser fulvescens*) and mudpuppies (*Necturus maculosus*), in laboratory and field exposures. *J. Great Lakes Res.* **29**: 529-541.

Lake sturgeon of several developmental stages were exposed to a lampricide mixture of 3-trifluoromethyl-4-nitrophenol (TFM)/1% niclosamide and to TFM only to determine potential toxic effects. Sac fry were most resistant followed by 200-225 mm fingerlings. Free swimming fry and fingerlings below 100 mm were most sensitive. Concentrations causing 50% mortality (LC50s) to sturgeon below 100 mm (except sac fry) were less than the minimum lethal concentrations (MLCs) needed to control sea lamprey larvae for both TFM and the TFM/1% niclosamide mixture. For lake sturgeon 100 mm or greater, the No Observed Effect Concentrations (NOECs) were equal to or greater than the MLCs for larval sea lamprey, indicating they would suffer only minimal mortality.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. *Environ. Biol. Fishes* **48**: 399-405.

The author discussed the current status of sturgeon and paddlefish populations in North America. The reproductive potential of Atlantic, white, and shortnose sturgeon, and paddlefish were more sensitive to fishing mortality than three other fish, namely striped bass, winter flounder, and bluefish. The main reasons were that sturgeon and paddlefish have long life spans, mature at an older age, have lower maximum fecundity, and older ages at which 50% of the lifetime egg production is realized with no fishing mortality.

Borkholder, B.D., Morse, S.D., Weaver, H.T., Hugill, R.A., Linder, A.T., Schwarzkopf, L.M., Perrault, T.E., Zacher, M.J., and Frank, J.A. 2002. Evidence of a year-round resident population of lake sturgeon in the Kettle River, Minnesota, based on radiotelemetry and tagging. *N. Am. J. Fish. Manag.* **22**: 888-894.

The objectives of this study were to determine if the tagged lake sturgeon were seasonal or year-round residents of the Kettle River, and to examine their seasonal movements, response to changes in discharge, and activity centers. In addition, the response of the fish to the removal of an 87-year old hydroelectric dam was monitored. Eight fish implanted with transmitters were tracked for seven months. Only five fish were located after this period and were monitored weekly from April of 1995 to September of 1996. The lake sturgeon remained within a 20 mile reach despite the absence of physical barriers at either end. Upstream movements occurred during rising discharges and downstream movements occurred during falling discharges. Approximately 80% of the weekly daytime observations occurred within 4 activity centers. The lake sturgeon population in the Kettle River appeared to be small and there was little mixing with adjacent populations.

Borkholder, B.D., Weaver, H.T., Morse, S.D., Linder, A.T., and Hugill, R.A. Date unknown. Movements of lake sturgeon in the Kettle River, Minnesota, based upon radio-telemetry. Fond du Lac Division of Resource Management, Cloquet, MN, Minnesota Department of Natural Resources, Hinkley Area Office, Fish and Wildlife Restoration Program, Washington, D.C. Pagination unknown.

This document was not available for annotating.

Bott, K., DeHaan, P.W., Forsythe, P.S., Meronek, T., and Scribner, K.T. 2005. Relative contributions of spawning stocks of lake sturgeon to populations in Lake Michigan, p. 7. In 2005 abstracts of oral presentations, Canadian Conference for Fisheries Research and the Society of Canadian Limnologists 2005 meeting, Windsor, Ontario, 6-9 January, 2005. [Abstract only]. Available from www.phys.ocean.dal.ca/ccfr/ [accessed 30 March 2006].

Bouchard, H.J.I., and Aloisi, D.B. 2002. Investigations in concurrent disinfection and de-adhesion of lake sturgeon eggs. *N. Am. J. Aquac.* **64**: 212-216.

Two methods of egg de-adhesion were used on two separate groups of lake sturgeon eggs before disinfection with 100 mg/l of iodine for 10 minutes. The de-adhesion of eggs with urea-NaCl-tannic acid solution produced a hatch survival rate of 77.2% and a 14-day post-hatch survival rate of 71%. Three methods of de-adhesion were then performed, including a solution of distilled water (jelly inhibitor) and iodine, a solution of urea, NaCl, and tannic acid, and a solution of Fuller's Earth and iodine. In all three methods the eggs were disinfected with a 50 mg/L buffered iodine solution for 30 minutes during or immediately after de-adhesion. Survival to hatchout was as follows: distilled water, 95.3%, urea-NaCl-tannic acid, 99.6%, and Fuller's earth, 97.7%. Survival to 14 day posthatch was as follows: distilled water, 76.8%, urea-NaCl-tannic acid, 84.2%, and Fuller's earth, 85.6%. Iodine disinfection during de-adhesion and water absorption processes did not appear to be toxic to lake sturgeon. However, topical iodine disinfection of lake sturgeon eggs, less than 10 minutes after fertilization, increased exposure of internal and external portions of the egg to the iodine during hydration of the egg envelope.

Boucher, R., Roy, D., and Magnin, E. 1984. Facteurs influençant le déplacement des poissons dans la partie aval de la Grande Rivière à la suite de la fermeture du barrage LG2. *Can. Water Resour. J.* **9**: 38-46.

When the La Grande River was cut off at the LG2 main dam, a saline front resulted. This front advanced 31 km between November 27, 1978 and early April 1979. It retreated 6 km from the mouth of the river in May, rose approximately 20

km in July, and returned to an area near the river mouth by November 1979. Mesh nets were set at 6 stations and the movements of three marine species (*Gadus ogac*, *Myoxocephalus quadricornis*, and *M. scorpius*), seven freshwater species (*Acipenser fulvescens*, *Salvelinus namaycush*, *Esox lucius*, *Couesius plumbeus*, *Catostomus commersoni*, *Percopsis omiscomaycus*, and *Stizostedion vitreum*), and six species tolerant of high salinity (*Salvelinus fontinalis*, *Coregonus artedii*, *Coregonus clupeaformis*, *Prosopium cylindraceum*, *Catostomus catostomus*, and *Lota lota*) were followed. It was found that movements due to salinity and water temperature changes were superimposed on the movements observed before the river was cut off.

Boudreau, P., Leclerc, M., and Secretan, Y. 2004. Centrale de l'Eastmain-1-A et dérivation Rupert - Simulation des habitats de reproduction piscicole de la rivière Rupert avec HYDROSIM/MODELEUR. Report prepared for Hydro-Québec and the Société d'Énergie de la Baie James. Report **INRS-ETE #R-732**: xii + 60 p.

A two-dimensional habitat model was applied at two reaches of the Rupert River to determine a hydrological regime that would promote the conservation of spawning habitats for lake sturgeon, walleye, longnose and white suckers, and lake whitefish. The TELEMAT-2D and HYDROSIM modeling programs were operated independently and results indicated similar flow patterns with some local differences. Habitat maps were produced with regression curves demonstrating the relationship between habitat availability and flow discharge during sensitive time periods of the life cycle of the fish species.

Boumhounan Committee. 2005a. Boumhounan News Flash. Eastmain-1-A Powerhouse and Rupert Division. Société d'énergie de la Baie James. 6 May 2005. 2 p. [Newsletter].

The Boumhounan News Flash is a newsletter about the Eastmain-1-A powerhouse and Rupert diversion environmental impact assessment. This issue discussed impacts and mitigation for fish populations in the Rupert and Misticawissich rivers. Fifteen fish species are found in the area. Lake sturgeon are found only in the forebay sections of the Rupert and Misticawissich Rivers, but are expected to appear in the tailbay

over time. Two lake sturgeon spawning grounds will be created, one on the Rupert River and one on the Misticawissich River. These will replace the two spawning grounds that will be lost by creation of the diversion bays.

Boumhounan Committee. 2005b. Boumhounan News Flash. Eastmain-1-A Powerhouse and Rupert Division. Société d'énergie de la Baie James. 7 June 2005. 2 p. [Newsletter].

The Boumhounan News Flash is a newsletter about the Eastmain-1-A powerhouse and Rupert diversion environmental impact assessment. This issue discussed impacts and mitigation for fish populations in the lower Rupert, Nemiscau and Lemare Rivers and the increased flow section. There are 22 species of fish in the lower Rupert River with lake sturgeon being one of the 5 most common. The environmental impact statement identified 11 spawning areas used by lake sturgeon. Mitigation measures are listed and include the stocking of lake sturgeon fry into the Rupert River.

Bourguignon, G. 1989. Les marches mondiaux de l'esturgeon chair et caviar. Publ. Dept Halieut. École Natn. Super. Agron. Rennes (France). 76 p.

This document was not available for annotating.

Bouton, D., and Stegemann, E. 1993. Endangered and threatened fishes of New York. Thirteenth in a series. The Conservationist **September**: 14-21.

This article reported the various species of fish in New York State that were threatened or endangered. The shortnose sturgeon was listed as endangered. Population decline was caused by overexploitation, pollution causing oxygen depletion, dams, and impoundments. The lake sturgeon was listed as threatened, and its populations had declined for the same reasons.

Branchaud, A., Gendron, A.D., Lemire, C., and Dion, R. 1996. Artificial spawning of lake sturgeon in northern Québec. Final report on spring 1995 research presented to the James Bay Mercury Committee, Montréal, Québec. v + 24 p.

This report is available in French and English. The objective of this study was to evaluate the

feasibility of using artificial spawning techniques on lake sturgeon in remote regions. The study took place in the spring of 1995 along the Broadback River. The brood stock was gillnetted between May 25 and May 31 during the spawning migration. Carp pituitary extract (CPE) was injected to induce final maturation. This hormone injection worked for 5 of the 6 females and 3 of the 4 males injected. The response time for females was approximately 29 hours at a water temperature range of 11.5-13.4°C. A total of 164,230 eggs were collected by caesarean section. Fertilization percentages ranged from 70%-89%, and hatching occurred an average of 6 days after fertilization. Detailed methods are provided in the report. This study demonstrated that hormone induction is a feasible option for lake sturgeon in remote regions.

Branchaud, A., Spear, P.D., Gendron, A.D., Fortin, R., and Anderson, P.D. 1993. Vitamin A (retinoids), malformations and contamination in white sucker and lake sturgeon around Montréal Island, p. 44. *In* 14th Annual Meeting (SETAC)-Ecological Risk Assessment: Lessons Learned? Abstract Book. [Abstract only].

The effects of contaminants on hepatic and ovarian vitamin A stores of lake sturgeon and white sucker were investigated. Retinoids were measured by reversed-phase high performance liquid chromatography. Contaminated lake sturgeon stored significantly less didehydroretinyl palmitate than the reference fish. Ovarian retinoid concentrations varied between polluted and reference sites for lake sturgeon.

Breck, J.E., and Hay-Chmielewski, E. 2003. Study performance report: pond rearing of juvenile lake sturgeon. Michigan Department of Natural Resources, Project No. **F-80-R-4**: 2 p.

This report described work completed from October 2002 to September 2003. The purpose of the study was to determine the relationship between size, rearing density and growth rate and the survival of age-0 lake sturgeon, and to measure size-dependent vulnerability to piscivores. A pond experiment was carried out to determine the effect of adult largemouth bass on lake sturgeon in ponds with crayfish. Four ponds were stocked with 100 lake sturgeon each. Only one lake sturgeon survived. The authors rejected their hypothesis that the effects of

largemouth bass on crayfish would increase survival of age-0 lake sturgeon.

Breining, G. 2003. Rapid changes on the Red River. Minnesota Conservation Volunteer November-December: 45-51.

This article discussed the construction of rapids on the Red River at the site of the Riverside Dam in Grand Forks-East Grand Forks. Construction began in 2000 and was completed in 2001. Some 80,000 tonnes of boulders were added to the river downstream of the dam. Lake sturgeon were once abundant in the Red River, overwintering in its deep, slow pools and migrating upstream to spawn in its tributaries (such as the Otter Tail River). There are 9 dams on the Red River, and many other fish barriers. These prevented sturgeon from accessing overwintering pools and spawning areas and in so doing, have contributed to the decline of the species. By the mid-1900s, lake sturgeon had essentially disappeared from the Red River.

Bretecher, R.L. 1999. Lower Nelson River tributary fish utilization studies: Limestone River and Moondance Creek 1998. Report prepared by North/South Consultants Inc., Winnipeg, MB for Manitoba Hydro, Winnipeg, MB. ix + 56 p.

This report documented the 1998 results of an ongoing study to assess the effects of the construction and operation of the Limestone Generating Station on downstream fish populations. Two-direction weirs were employed on Limestone River and Moondance Creek to capture fish. A total of 5,041 fish were enumerated on the Limestone River. Lake sturgeon made up less than 1% of this catch, with a total of 3 being tagged (2 on September 4 and 1 on September 8). No lake sturgeon were captured in Moondance Creek.

Bretecher, R.L., and MacDonell, D.S. 1998. A fisheries investigation of the lower Nelson River 1997. An unpublished report prepared by North/South Consultants Inc., Winnipeg for Manitoba Hydro, Winnipeg, MB. v + 32 p.

The 1997 results of a study conducted to monitor the post-impact effects of the Limestone Generating Station on the lower Nelson River were presented. A total of 808 fish were caught with gillnets between September 2 and October 14. Fifteen species were represented, with lake sturgeon making up 1.4% of the catch. A total of

11 lake sturgeon were caught. Two of these were captured nearshore and measured 141 and 295 mm in length. These were the smallest non-larval lake sturgeon captured during investigations of the lower Nelson River dating back to the mid-1970s. Based on unpublished data from the Wolf River, Wisconsin, the authors speculated that the 145 mm sturgeon was from the 1997 year class and the 295 mm sturgeon was likely 1-2 years old.

Bretecher, R.L., and MacDonell, D.S. 2000. Lower Nelson River forebay monitoring program 1999. Unpublished report prepared by North/South Consultants Inc., Winnipeg for Manitoba Hydro, Winnipeg, MB. xii + 104 p.

The 1999 results of a multi-year study to monitor the response of fish populations to impoundment of a large northern river were presented. Gillnets were employed to sample Limestone Forebay (July 19-29), Long Spruce Forebay (July 29-August 3), and the lower area of Stephens Lake (Kettle Forebay) (August 11-19). Of 750 fish captured in Limestone Forebay, 2 were lake sturgeon (0.3%). Of 548 fish captured in Long Spruce Forebay, 4 were lake sturgeon (0.7%). No lake sturgeon were captured in Stephens Lake. Of the 4 sturgeon captured in Long Spruce Forebay, 3 were juveniles (2-3 years old). This was only the second time sturgeon younger than the forebay have been reported, indicating successful reproduction and/or augmentation from upstream of the Kettle Generating Station. Results were compared to those from previous years.

Bretecher, R.L., and MacDonell, D.S. 2001. Saskatchewan River lake sturgeon habitat investigation Cumberland House, Saskatchewan to The Pas, Manitoba June, 2000. Prepared by North/South Consultants Inc., Winnipeg for Manitoba Hydro, Winnipeg, MB. xiv + 124 p.

This study examined fish habitat (depth, velocity and substrate) in the Saskatchewan River between Bigstone Rapids and Summerberry River (downstream of The Pas), and assessed lake sturgeon habitat use. Habitat data were collected at 177 sites in Saskatchewan and 379 sites in Manitoba. Shoreline riparian characteristics were examined at 35 sites. Locations, data and detailed maps are included. Substrates consisted of sand with silt, gravel and/or cobble (73%), mud and silt (24%), and boulders, cobble and bedrock (<3%). Water

velocities ranged from 0.25 to 1.15 m/s. In Manitoba, maximum transect depths ranged from 0.90 to 18.00 m (mean=5.55 m). In Saskatchewan, maximum transect depths ranged from 0.90 to 7.55 m (mean=3.18 m). A total of 81 fish from the following 9 species were captured: northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), white sucker (*Catostomus commersoni*), lake sturgeon (*Acipenser fulvescens*), longnose sucker (*Catostomus catostomus*), goldeye (*Hiodon alosoides*), burbot (*Lota lota*), carp (*Cyprinus carpio*), and yellow perch (*Perca flavescens*). Two lake sturgeon were caught in Saskatchewan and one in Manitoba. Two were caught at a mean depth of 3.59 m and a mean water velocity of 1.04 m/s (highest of any transect in study area), over a substrate of hard packed sand mixed with cobble, gravel and boulders. The remaining sturgeon was caught at a mean depth of 6.15 m and a mean water velocity of 0.50 m/s, over a substrate of sand mixed with a small amount of gravel and silt. Bigstone Rapids, Saskatchewan, was the only area found to contain suitable lake sturgeon spawning habitat. The absence of sturgeon at this known spawning site may have been due to the fact that optimum spawning temperature (13-18°C) was not reached until after the study ended, and average flow volumes were less than half the historical average. The possibility of the existence of a domestic fishery that could have significant effects on the lake sturgeon population was briefly discussed.

Brice, J.J. 1898. A manual of fish culture based on the methods of the United States Commission of Fish and Fisheries. Rep. U.S. Comm. Fish Fisheries 23: 189-191.

A brief discussion of the sturgeon fishery in the United States was given. The six species of sturgeon were the common, short-nose, Atlantic, white, green and lake or rock, with the most valuable being the common and lake sturgeons. Sturgeon were caught with gill and pound nets, seines, and set lines. The main fisheries were the Great Lakes and the Delaware and Sacramento rivers with a value of \$300,000. Secondary products included caviar, isinglass, and oil. The author discussed the rapid decline (60-80%) in the sturgeon fishery in a single decade. While an individual common sturgeon could weigh 500 pounds, lake sturgeon 200 pounds, and Pacific sturgeon 848 pounds, current catches had much lower weights. The

collection and incubation of fertilized eggs was discussed. Treating the eggs with starch particles or swamp muck was the best way to prevent clumping. Under hatchery conditions eggs were attached by fungi. The incubation period was 7 days in water at 62 to 66°F. Brackish water was noted to be better than freshwater for incubation.

Bronte, C.R., Ebener, M.P., Schreiner, D.R., DeVault, D.S., Petzold, M.M., Jensen, D.A., Richards, C., and Lozano, S.J. 2003. Fish community change in Lake Superior, 1970-2000. Can. J. Fish. Aquat. Sci. 60: 1552-1574.

This study documented changes in the fish community of Lake Superior from 1970 to 2000. Potential stressors included habitat degradation, contaminants, phosphorus loading, global warming, exotic species, intentionally introduced non-native species, and fishery exploitation. The expected impacts of these stressors were compared to observed changes. The lake sturgeon was listed as an inshore species affected by habitat loss.

Brooking, T.E. 2000a. Summary of gillnet sizes used for lake sturgeon - based on an e-mail survey of researchers. Cornell University Field Station, Bridgeport, NY. 8 p. Available from <http://www.fws.gov/midwest/sturgeon/cornellstngntsiz.html> [accessed 30 March 2006].

The author conducted an e-mail survey of sturgeon researchers to learn the sizes and types of nets used for capturing juvenile and adult sturgeon. Based on the results, monofilament gillnets 88 m long with 8 panels each 11 m long and with the following mesh sizes: 6, 8, 10, and 12" were chosen. This type of net is effective for sturgeon 900 - 1,200 mm long. The results of the survey, and comments from researchers, were presented.

Brooking, T.E. (ed.) 2000b. Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. Cornell University Biological Field Station, Bridgeport, NY. 17p. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 30 March 2006].

Eleven abstracts were included in this document. The titles are as follows: A Recovery

Plan for the Lake Sturgeon in New York State; USFWS Lake Sturgeon Program Summary; Update on Lake Sturgeon in Canadian Waters of Lake Ontario and the St. Lawrence River, January 2000; Lake Sturgeon Spawning on Artificial Habitat in the St. Lawrence River; Summary of Lake Sturgeon Research Efforts in the St. Lawrence and Grasse River Systems; Lake Sturgeon Restoration Research Project in the Genesee River; Oswegatchie River Lake Sturgeon Restoration Project; Sea Lamprey Management Program and Lake Sturgeon; Stocked Sturgeon in Cayuga Lake; Growth, Habitat Use and Diet of Re-Introduced Lake Sturgeon in Oneida Lake, NY; and NYS Oneida Fish Hatchery Lake Sturgeon Stocking History.

Brooking, T.E., VanDeValk, A.J., and Rudstam, L.G. 2000. Growth, habitat use and diet of re-introduced lake sturgeon in Oneida Lake, NY, p. 15-16. *In* T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 30 March 2006].

Brousseau, C.S. 1987. The lake sturgeon (*Acipenser fulvescens*) in Ontario, p. 2-9. *In* C. H. Olver (ed.) Proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23.

Overfishing and habitat decline were considered the major causes for the decline of lake sturgeon populations in Ontario. The commercial yield dropped from over 816,000 kg in 1885 to less than 10,000 kg in recent years. The species slow rate of growth and late age at maturity made it particularly vulnerable to overexploitation. There were only a few places in Ontario that sustained sturgeon abundant enough to support a sport fishery. Unexploited populations in favourable habitats may yield only 0.2 kg/hectare. The future of lake sturgeon in Ontario was considered bleak, since current regulations were inadequate to protect this species from stock depletion and immediate and significant changes were urged.

Brousseau, C.S., and Goodchild, G.A. 1989. Fisheries and yields in the Moose River basin, Ontario, p. 145-158. *In* D. P. Dodge (ed.)

Proceedings of the International Large River Symposium (LARS), Honey Harbour, Ontario, Sept. 14-21, 1986. Can. Spec. Publ. Fish. Aquat. Sci. 106.

The fisheries of the important tributaries of the Moose River basin in Ontario and their physiogeographic features were reviewed. Lake sturgeon was reported from all six river systems. Water fluctuations between dams had caused a decline in lake sturgeon populations and low water conditions immediately after spawning produced variable water temperatures and low oxygen. Fry became trapped in shallow pools and were subjected to mortality due to predation and environmental stress. Sauger and lake sturgeon were the species most vulnerable to hydroelectric effects. Rapid flushing of systems affected sturgeon; at Adams Creek sturgeon were washed over the spillway during high flow rates and during spawning. When the discharge was stopped, sturgeon were left stranded. Estimates of lake sturgeon in a 14 km reach of the Frederick House River were <3.3 fish/ha and lake sturgeon were estimated to comprise 37% of the biomass. Standing stock estimates of lake sturgeon from Frederick House, Abitibi, Groundhog and two sites on the Mattagami River ranged from 0.17 to 7.2 fish/ha with corresponding standing stocks of 1.0-84.7 kg/ha. The Mattagami population was low and appeared to be affected by water level fluctuations during spawning, and by commercial over-harvesting. The Moose River may only sustain a harvest of 1.8% of the population per annum. Eighty per cent of the lake sturgeon recaptured in the Moose River were taken within 1 km of the tagging location, and most moved less than 5 km over a 3 year period. This made them especially vulnerable to exploitation.

Brown, J.R. 1991. Molecular evolution and population genetics of sturgeon, Genus *Acipenser*, based on mitochondrial DNA analysis. Ph.D. Thesis, Simon Fraser University, Burnaby, BC. xii + 191 p.

This document was not available for annotating.

Brown, J.R., Beckenbach, K., Beckenbach, A.T., and Smith, M.J. 1996. Length variation, heteroplasmy and sequence divergence in the mitochondrial DNA of four species of sturgeon (*Acipenser*). *Genetics* 142: 525-535.

The extent of mtDNA length variation and heteroplasmy were examined in *A. transmontanus*, *A. medirostris*, *A. fulvescens*, and *A. oxyrhynchus*. A division in the occurrence of length variation and heteroplasmy was observed across the continental divide. This was in agreement with species biogeography as well as with phylogenies based on restriction fragment length polymorphisms of whole mtDNA and pairwise comparisons of unique sequences of the control region. MtDNA length variation was due to repeated arrays of 78-82-bp sequences with a D-loop strand synthesis termination associated sequence (TAS) in all four species. Individual repeats showed greater sequence conservation within individuals and species than between species, suggesting concerted evolution. Differences in the frequencies of multiple copy genomes and heteroplasmy between the species were attributed to differences in rates of recurrent mutation. A mechanism that may offset the high rate of mutation for increased copy number was given, on the basis that an increase in number of functional TAS motifs may reduce the frequency of successfully initiated H-strand replications.

Bruch, R.M. 1994. Eighty years of lake sturgeon management on the Lake Winnebago system, p. 6-7. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Bruch, R.M. 1997a. Long term impacts of harvest and regulations on lake sturgeon population structure - Winnebago System., p. 451. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, WI., December 7-10, 1997. [Abstract only].

Bruch, R.M. 1997b. Management of lake sturgeon on the Winnebago system - long term impacts of harvest and regulations on population structure. *In* Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

Bruch, R.M. 1998. Management and trade of lake sturgeon in North America. Presented at the Symposium on the Harvest, Trade and Conservation of North American Paddlefish and Sturgeon, May 7-8, 1998, Chattanooga, TN. 11 p. + figs.

This paper reviewed the current status of management and trade of lake sturgeon in North America, and discussed a model of management using the Winnebago System sturgeon program as an example. The author attributed the success of this program to the construction of 40 spawning sites that contributed to natural reproduction and recruitment. The involvement of the public has also contributed greatly to the success of the program.

Bruch, R.M. 1999. Management of lake sturgeon on the Winnebago System - long term impacts of harvest and regulations on population structure. *J. Appl. Ichthyol.* **15**: 142-152.

Recent assessments of the lake sturgeon in the Winnebago system revealed that adult females were being overexploited. Between 1991 and 1997, 13,714 sturgeon were assessed by sampling and spawning surveys to determine the status of the current population. Historical data were obtained from DNR files and the last 40 years were analyzed. Estimated annual exploitation of adult females was 2 to 3 times higher than that of adult males. The benefits of conservative bag limits in combination with shorter harvesting seasons, strict law enforcement, and habitat conservation were seen in the four fold increase in stock densities from 1955 to 1990. The author recommended public involvement and the standardization of long term harvest and population assessments, for the successful management of sturgeon populations.

Bruch, R. 2004a. Lake sturgeon Winnebago system - sportfish restoration status reports, July 2003 - June 2004. Wisconsin Department of Natural Resources, Madison, WI. 9 p.

This document was not available for annotating.

Bruch, R.M. 2004b. Management of lake sturgeon on the Lake Winnebago system, Wisconsin. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The Winnebago system has supported a recreational sturgeon winter spear fishery since 1931. The fishery averaged over 1,000 sturgeon per year during a 2 to 16 day season. Population and harvest assessment, habitat

development and enhancement, law enforcement, and public involvement all contributed to the success of the fishery. Annual assessments provided estimates of spawning stock densities and a direct account of the harvest. Citizen volunteers patrolled spawning sites during the spring, and the Citizens Advisory Committee aided in the development of regulation and management program changes. There was a harvest cap with no limitations on spear fishing license sales at the time of this report.

Bruch, R.M. 2004c. One hundred years of sturgeon management - history of the Winnebago sturgeon program. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The Winnebago system lake sturgeon population has been actively managed since 1903 when the first harvest restriction (8 lb minimum size limit) was enforced. Harvest and population assessments over the last 60 years allowed for the analysis of population trends and the successful maintenance of an assessment program and harvest regulations. Water quality improvements, increases in minimum size limits, and increases in popularity have led to the overexploitation of adult female sturgeon. Annual exploitation was at or below 5% through harvest caps and season reductions.

Bruch, R.M., and Binkowski, F.P. 2002. Spawning behavior of lake sturgeon (*Acipenser fulvescens*). *J. Appl. Ichthyol.* **18**: 570-579.

Lake sturgeon spawning behaviour was studied over a 16 year period in the Wolf and upper Fox rivers, Wisconsin. The spawning behaviour of male and female lake sturgeon was directly related to water temperature. When water temperatures rose from 6.6 to 16°C sturgeon began showing a porpoising behaviour near the spawning grounds. This behaviour increased as water temperature rose. Within the temperature range of 8.8 to 16.0°C males moved into the spawning ground and appeared to search for ovulating females. Females appeared on spawning grounds at water temperatures ranging from 8.8 to 19.1°C. Although peak spawning activity occurred at temperatures from 11.5 to 16.0°C, they spawned at all hours with temperatures ranging from 8.8 to 21.1°C. Males were the first to arrive but females determined

the length of spawning by their timing and spawning ground use. Females appeared to give cues to males for 2-4 spawning bouts where a small number of eggs were released by the female into a mass of sperm from 2 to 8 males. Spawning bouts were initiated every 1.5 minutes by females and oviposition continued for 8 to 12 hours. Spawning was observed to occur for 2-4 days on each site. Males beat the abdomen of the females while ejaculating, and made a vibrating sound to attract other males to the site. In addition, the rate of increase in water temperature affected the actual temperature at which spawning began. The authors concluded that sturgeon exhibited complex polygamous mating behavior, and their breeding system was polyandrous and polygynous, the end result being the preservation of genetic diversity.

Bruch, R.M., Binkowski, F., Dick, T.A., and Choudhury, A. 1994. Stages of lake sturgeon gonad development and management implications, p. 6. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Bruch, R.M., Dick, T.A., and Choudhury, A. 2001. A field guide for the identification of stages of gonad development in lake sturgeon (*Acipenser fulvescens* Rafinesque), with notes on lake sturgeon reproductive biology and management implications. Sturgeon for Tomorrow, Wisconsin Department of Natural Resources and University of Manitoba. 38 p.

Lake sturgeon gonads were examined from populations in the Lake Winnebago System in Wisconsin USA, the Winnipeg and Nelson rivers, Manitoba, and the Saskatchewan River, Saskatchewan. The Wisconsin samples were mostly pre-spawn samples collected in February and the Canadian samples were mostly post-spawn summer samples. The stage of gonad development was based on freshly collected samples and from tissues fixed for histology and then examined with a compound microscope. Most of the 64 figures in the document are in colour. Two diagrams illustrate the stages of development of female and male lake sturgeon, from virgin females and males to post-spawning adults. Spawning characteristics of lake sturgeon were discussed. The importance of determining sex, maturity and age of harvested fish, and the age of first spawning females and

males were emphasized as important tools for lake sturgeon management.

Bubenik, G., and Pang, S.F. 1997. Melatonin levels in the gastrointestinal tissues of fish, amphibians, and a reptile. *Gen. Comp. Endocrinol.* **106**: 415-419.

Melatonin was detected in the gastrointestinal tract (GIT) of sturgeon, rainbow trout, carp, axolotl leopard frog, bullfrog and the red-sided garter snake using radioimmunoassay. The highest levels of melatonin were detected in the snake and carp (means = 1,018 pg/g stomach, 328 pg/g proximal gut, 511 pg/g distal gut, and means = 102 pg/g stomach, 146 pg/g proximal gut, and 141 pg/g distal gut, respectively). Lowest levels were found in the axolotl and bullfrog (means = 44 pg/g stomach and proximal gut and 92 pg/g distal gut, and means = 73 pg/g esophagus, 78 pg/g stomach, 20 pg/g proximal gut, and 152 pg/g distal gut, respectively). Statistically significant differences were found in tissue levels between different species and not among GIT tissue of the same species.

Buddington, R.K. 1985. Digestive secretions of lake sturgeon, *Acipenser fulvescens*, during early development. *J. Fish Biol.* **26**: 715-723.

Lake sturgeon exhibit embryonic and larval development similar to white sturgeon and because of that the author speculated that digestion should be similar. Larval fish were fed starting day 12 post hatch with tubificid worms until 60 days post hatch. Fish were sampled on days 18, 22, 26, 30, 36, and 60 post hatch by removing the entire alimentary canal and separating it into anatomically distinct sections. Samples were pooled and protein concentration determined. Enzymes assayed for were trypsin, chymotrypsin, pepsin, alpha amylase, and lipolytic enzymes. During the yolk stage (day 1-16) yolk proteins were preferentially assimilated into tissues and lipids were conserved. This was evident by the accumulation of oil droplets in the gut. The larval feeding phase (day 16-24) was characterized by high amylolytic and lipolytic activities. Tryptic proteolysis was supplemented by gastric secretion of acid and pepsin and increased chymotrypsin. The gastric region of lake sturgeon appeared to be functional at the onset of feeding. There was an enzymatic shift at metamorphosis, specifically lipase and amylase, and chymotrypsin concentrations decreased while pepsin and trypsin continued to

increase. Digestive capabilities of sturgeon appeared to be higher than for other teleosts prior to metamorphosis, and the availability of carbohydrates and lipids to larval sturgeon may also have been higher relative to juvenile and adults. Most digestion took place in the spiral valve. Natural foods were high in lipids (up to 56%) and elevated lipolytic activity during larval feeding could have enhanced utilization of the high dietary lipid levels. Following metamorphosis lipid and protein requirements declined and there was an increased dependence on protein catabolism.

Bureau of Commercial Fisheries. [1959?] Great Lakes Fishery Statistics 1932-1958. United States Department of the Interior. Various pagination.

This document presented fisheries statistics for the Great Lakes from 1932 to 1958. The statistics were broken down by Country (US or Canada), lake, and state (provinces were not included). Harvests were given in pounds and dollar value. Summaries of operating units by state and lake were included.

Buroker, N.E., Brown, J.R., Gilbert, T.A., O'Hara, P.J., Beckenbach, A.T., Thomas, W.K., and Smith, M.J. 1990. Length heteroplasmy of sturgeon mitochondrial DNA: an illegitimate elongation model. *Genetics* **124**: 157-163.

The D-loop region of two extreme length variants of white sturgeon (*Acipenser transmontanus*) mitochondrial DNA (mtDNA) was cloned and sequenced. The D-loop region of white sturgeon DNA shows length polymorphism and heteroplasmy. Sequencing showed that the differences are due to various numbers of a perfect 82 base pair direct repeat. The authors propose a model for the differences which contends that length heteroplasmy may be due to "frequent competitive misalignment" (pg. 157) in the repeat region before replication.

Bykhovskaya-Pavlovskaya, I.E., Gusev, A.V., Dubinina, M.N., Izyumova, N.A., Smirnova, T.S., Skolovskaya, I.L., Shtein, G.A., Shul'man, S.S., and Epshtein, V.M. 1962. Phylum Coelenterata, p. 237-238, 240. *In* Key to parasites of freshwater fishes of the U.S.S.R. Academy of Sciences of the U.S.S.R. Zoology Institute. Israel Program of Scientific Translation, Jerusalem, 1964, Cat. No. 1136.

This work contained a section on coelenterates with a brief summary of the life cycle of *Polypodium hydriforme*, the only coelenterate parasite reported in the book. The exact taxonomic position was not clarified. A schematic figure of the life cycle was provided.

Cable, R.M. 1952. On the systematic positions of the genus *Deropristis*, of *Dihemistephanus sturionis* Little, 1930, and of a new digenetic trematode from a sturgeon. *Parasitology* **42**: 85-91.

Cable erected a new genus *Pristotrema*, for digeneans from two specimens of *Scaphirhynchus platyrhynchus* (shovel-nosed sturgeon), and *Pristotrema manteri* was described with diagrams as the type and only species. The lake sturgeon "*Acipenser rubicundus*" was listed as a possible definitive host. This was suggested by Ward's (1938) reference to trematodes which Stafford (1904) reported as *Deropristis hispidus*. Based on the descriptions of Stafford for this trematode, Cable agreed with Ward that Stafford was dealing with a species not even belonging to the genus *Deropristis*. Ward possessed a trematode specimen from lake sturgeon similar to Stafford's but never described it. An incomplete search through Ward's collection did not yield this specimen. A re-study of Stafford's collection by Miller (1941) did not add to the information. Since Stafford's brief description agrees with that of *Pristotrema* by Cable, it was considered possibly as being Cable's *P. manteri*.

Cable, R.M. 1955. Taxonomy of some digenetic trematodes from sturgeons. *J. Parasitol.* **42**: 441.

The confusion arising from two generic names erected for the same type of sturgeon trematode was clarified. The genus *Skrjabinopsolus* was erected in Russia (authority considered uncertain but probably Ivanov, in Ivanov and Murygin 1937), while *Pristotrema* was proposed in North America by Cable (1952). Since *Skrjabinopsolus* had priority over *Pristotrema*, *Pristotrema manteri* became *Skrjabinopsolus manteri* (Cable, 1952).

Campbell, R.R. 1990. Rare and endangered fishes and marine mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee status reports: VI. *Can. Field Nat.* **104**: 1-6.

The lake sturgeon was listed as NIAC (not in any category of COSEWIC designations). This status was assigned in 1986 and was valid up to April 1989. The lake sturgeon was also listed as a species for which status reports are in preparation or under review as of August 1989 and a question mark (?) appears under "Proposed Status".

Campbell, R.R. 1993. Rare and endangered fishes and marine mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee status reports IX. *Can. Field Nat.* **107**: 395-401.

As of April of 1993 lake sturgeon were listed as RANSR, meaning "report accepted no status designation required". The lake sturgeon was also listed as a species for which a status report was being prepared, with a question mark under "Proposed Status".

Campbell, R. 2005. Comments on the draft EIS for the EM-LA/Rupert Diversion Project - as related to lake sturgeon (*Acipenser fulvescens*). Memorandum from the Cree Regional Authority. 12 p. Available from http://www.bip-pio.qc.ca/_tsdocument/COE%20B014-EN.pdf [accessed 30 March 2006].

The concerns of the Cree Regional Authority regarding the Eastmain 1A-Rupert Diversion hydroelectric project Environmental Impact Statement (EIS) were summarized. Their main concerns were that the EIS assumed no degree of risk to sturgeon in the area, that studies of fish communities only documented presence/absence and lacked other detail (e.g. population dynamics, nursery habitat and parasites were not considered), and that mitigation should consider the establishment of an aquaculture facility.

Canada, Department of Fisheries and Oceans. Date unknown. Lake sturgeon in the Prairie Provinces: life history and threats to habitat. Central and Arctic Region, Winnipeg, MB. 5 p. [Brochure].

The life history of lake sturgeon, the causes of their rapid population decline, and problems affecting their survival in the Prairie Provinces were discussed.

Canada, Department of Justice. 1987. *Manitoba Fishery Regulations, 1987.* **SOR/87-509:** 35 p. Available from <http://laws.justice.gc.ca/en/F-14/SOR-87-509/221995.html> [accessed 24 September 2006].

Fishing for lake sturgeon in the Winnipeg River, between the Manitoba-Ontario border and the Pine Falls Generating Station, was listed as being restricted from January 1 to December 31. Similar harvest restrictions were placed on the Nelson River and its tributaries, from Whitemud Falls to Kelsey Generating Station, including Duck and Sipiweesk lakes, and any other waters.

Canada, Department of Marine and Fisheries. 1873. p. 193-195. *In* Sixth annual report of the Canada Department of Marine and Fisheries Sessional Paper No. 8.

In 1873, Urquhart reported sturgeon in Lake of the Woods, Rainy Lake, areas between Lake Superior and the province of Manitoba, east of Grand Rapids, the Red River, and the Assiniboine River near Fort Garry. Fish weighing 60 to 80 lbs were frequently caught, and sturgeon oil was commonly extracted.

Canada, Department of Marine and Fisheries. 1881. Supplement No. 2 to the Eleventh Annual Report of the Minister of Marine and Fisheries for the Year 1880. Fisheries Statements for the Year 1880.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1880 included Québec and Ontario.

Canada, Department of Marine and Fisheries. 1893. Supplement No. 4 to the Annual Report of the Department of Marine and Fisheries. Fisheries Statements and Inspectors' Reports for the Year 1892.

Provinces and Territories that reported a commercial harvest of sturgeon in 1892 included Manitoba, Ontario, Québec and the Northwest Territories.

Canada, Department of Marine and Fisheries. 1900. Thirty-second Annual Report of the Department of Marine and Fisheries. 1899 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces and Territories that reported a commercial harvest of sturgeon in 1898 included Manitoba, Ontario, Québec and the Northwest Territories.

Canada, Department of Marine and Fisheries. 1902. p. 163-166. *In* Thirty-fourth annual report of the Department of Marine and Fisheries. Sessional Paper No. 22.

Fishery statistics for Manitoba for the year 1900 were reported. Season conditions were profitable, with a total of 981,500 pounds of sturgeon caught in Lake Winnipeg and its tributaries with a value of \$58,890.

Canada, Department of Marine and Fisheries. 1903. p. 119-123. *In* Thirty-fifth annual report of the Department of Marine and Fisheries. Sessional Paper No. 22.

In 1901, the Manitoba sturgeon harvest was 600,000 pounds, a decline of 381,500 pounds from the previous year, with a value of \$36,000. This decline was attributed to high water levels in lakes during the fishing season (three feet higher than previous years).

Canada, Department of Marine and Fisheries. 1904. p. 197-202. *In* Thirty-sixth annual report of the Department of Marine and Fisheries. Sessional Paper No. 22.

In 1902, 600,000 pounds of sturgeon were caught in Manitoba waters, with a value of \$60,000. Some sturgeon were caught at the mouth of the Winnipeg River, and some were caught by hook by Aboriginal fishermen.

Canada, Department of Marine and Fisheries. 1905. Thirty-seventh Annual Report of the Department of Marine and Fisheries. 1904 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces and Territories that reported a commercial harvest of sturgeon in 1904 included Manitoba, Ontario, Québec and the Northwest Territories.

Canada, Department of Marine and Fisheries. 1906a. p. 190-194. *In* Thirty-eighth annual report of the Department of Marine and Fisheries. Sessional Paper No. 22.

The author noted that sturgeon appeared to be getting fewer in number each year in Manitoba, and suggested setting aside the Winnipeg River as a spawning ground, because many young sturgeon had been seen there. The weight and value of the 1904 catch were consistent with the previous fishing season.

Canada, Department of Marine and Fisheries. 1906b. Thirty-ninth Annual Report of the Department of Marine and Fisheries. 1906 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1906 included Manitoba, Ontario, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1907. Fortieth Annual Report of the Department of Marine and Fisheries. 1907 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1907 included Manitoba, Ontario, Alberta, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1909a. Forty-first Annual Report of the Department of Marine and Fisheries. 1907-8 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1907 and 1908 included Manitoba, Ontario, Alberta, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1909b. Forty-second Annual Report of the Department of Marine and Fisheries. 1908-9 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon 1908 and 1909 included Manitoba, Ontario, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1910. Forty-third Annual Report of the Department of Marine and Fisheries. 1909-10 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1909 and 1910 included Manitoba, Ontario, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1911. p. 284-287. *In* Forty-fourth annual report of the Department of Marine and Fisheries. Sessional Paper No. 22.

The sturgeon catch declined compared to previous years in Manitoba. By the end of the fiscal year (March 31) of 1911, 2,335 pounds of sturgeon had been caught with a value of \$32,690. In addition, \$8,000 in caviar had been harvested.

Canada, Department of Marine and Fisheries. 1912. Forty-fifth Annual Report of the Department of Marine and Fisheries. 1911-12 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1911 and 1912 included Ontario, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1914. Forty-seventh Annual Report of the Department of Marine and Fisheries. 1913-14 Fisheries.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1913 and 1914 included Ontario and Québec.

Canada, Department of Marine and Fisheries. 1921. Fifty-fourth Annual Report of the Fisheries Branch, Department of Marine and Fisheries, for the Year 1920.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1920 included Manitoba, Ontario, Saskatchewan and Québec.

Canada, Department of Marine and Fisheries. 1923. Fifty-sixth Annual Report of the Fisheries Branch, Department of Marine and Fisheries, for the Year 1922.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1922 included Manitoba, Ontario, Saskatchewan and Québec.

Canada, Department of the Naval Service. 1917. Fiftieth Annual Report of the Fisheries Branch, Department of the Naval Service, 1916-17.

Provinces that reported a commercial harvest of sturgeon in 1916 and 1917 included Manitoba, Ontario, Alberta, Saskatchewan and Québec.

Canada-United States International Joint Commission - International Garrison Diversion Study Board. 1976. Fish diseases and parasites, p. 128-135. In J. Loch and D. Henegar (ed.) Report to the International Joint Commission - 1976, Appendix C, Biology Committee final report - environmental impact assessment, alternatives and recommendations, attachments.

The impact of the introduction of fish species and potential pathogens into the Hudson Bay drainage from the Upper Missouri basin via the proposed McClusky Canal was discussed. The Biology Committee considered that shovelnose and pallid sturgeon, once established in Canadian waters, would compete with lake sturgeon populations for food and habitat. This impact could not be quantified and both these potential colonizers are rare and non-migratory (p. 115). The potential impact of the parasite *Polypodium* was also mentioned.

Carbone, J. 1985. 1981 and 1985 biological survey of the lower Kapuskasing River, Kapuskasing, Ontario. Technical memorandum to G. Myslik, Ontario Ministry of the Environment. Pagination unknown.

This document was not available for annotating.

Carlander, K.D. 1969. Lake sturgeon, *Acipenser fulvescens* Rafinesque, p. 33-45. In Handbook of freshwater fishery biology, Vol. 1. The Iowa State University Press, Ames, Iowa.

This set of data included weight, length, number, range of values, and regressions of growth on selected fish species. Data on lake sturgeon from across North America were presented. The largest female caught was 125 kg and from Lake Winnipeg. The largest male was 100 kg and caught in Lake Erie. Age was determined by sectioning fin rays. A tagged lake sturgeon of length 533 mm and weight 907 g grew to 610 mm and 2268 g in three years and five months; another sturgeon tagged at 6,350 g increased to 34,019 g in 28 years. Sturgeon from Lake Winnebago, Wisconsin appeared to grow at a rate above the average for North America. Sturgeon appeared to spawn every 4-7 years, and slower growth 2-3 years prior to spawning results in "belts" of good and poor growth. There was a definite periodicity in females, but some males spawned in consecutive years. The period between spawning for females was 4 years in Minnesota, 4-5 years in the St. Lawrence, and 6 years in Lake Nipigon. Spawning occurred from April 15 to May 15 in Minnesota at temperatures of 12-15°C. Spawning in Ontario occurred from early May to the end of June at temperatures of 12-19°C and in Québec from early May to the end of June at water temperatures of 18.4°C. The main food items were insect larvae, leeches, molluscs, isopods, and crustaceans.

Carlson, D.M. (principal investigator). 1981. Abundance and life history of lake, pallid, and shovelnose sturgeon in Missouri. Missouri Department of Conservation. Pagination unknown.

This document was not available for annotating.

Carlson, D.M. 1983. A description and comparison of larval sturgeon (*Scaphirhynchus* spp. and *Acipenser fulvescens*) from the central United States. Trans. Mont. Acad. Sci. 17: 19-26.

This report described the larvae of lake sturgeon and *Scaphirhynchus* spp. The larvae of the shovelnose sturgeon (*S. platyrhynchus*) and the pallid sturgeon (*S. albus*) could not be distinguished, so identification was to the genus level only. Diagrams, morphological comparisons, and a frequency distribution of myomere counts were included. The best distinguishing characteristics were pigmentation pattern, size at developmental stage, and total myomere counts.

Carlson, D.M. 1995. Lake sturgeon waters and fisheries in New York State. *J. Gt. Lakes Res.* 21 : 35-41.

An overview of records of lake sturgeon occurrences in New York State was conducted to assist in restoration planning. The species was identified in 17 water bodies of New York State in the Great Lakes drainage. These include Lakes Erie, Ontario, Champlain and the Niagara and St. Lawrence rivers. Two other rivers had self-sustaining populations, five had historically supported spawning runs, and five waters had historical records of use or relict populations. Lake Erie and Lake Ontario were the locations with the largest historic sturgeon fisheries in New York State. By the 1940s the Great Lakes fisheries were abandoned. Other remaining fisheries were abandoned by the 1960s. Lake sturgeon were self-sustaining at very low levels in the Upper Niagara, St. Lawrence, and Grasse rivers. These fish were protected from harvest in all areas but one, namely the St. Lawrence River downstream of Massena where the Akwesasne Reservation had a limited commercial harvest.

Carlson, D. 2000. A recovery plan for the lake sturgeon in New York state, p. 2-4. *In* T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.htm> [accessed 30 March 2006].

Carlson, D. 2003. Sturgeon stocking program. New York State Conservationist **December**: 11.

This was a short (one paragraph) discussion of the success of a lake sturgeon stocking program in New York State.

Carlson, D., Schiavone, A., and LaPan, S. 1994. Lake sturgeon restoration in northern New York rivers, p. 12. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Carrier, C., and Collin, P. 1993. Description des méthodes de pêche et des techniques d'échantillonnage pour acquisition de données

biologiques sur l'esturgeon jaune (*Acipenser fulvescens* Raf.). Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Sous-ministère des pêches et de l'aquiculture commerciales du Québec. vii + 58 p.

The authors presented a synthesis of the techniques used in acquiring biological data from lake sturgeon. The methods were described and the datasheets used were shown in order to harmonize data acquisition for this species. The included photographs provide a better understanding of the fishing and sampling methods.

Carson, R., and McKinley, R.S. 1998. Conceptual design of a protection scheme for lake sturgeon (*Acipenser fulvescens*). Ontario Hydro. 41 p.

This document was not available for annotating.

Carson, R.K., Sandilands, A., and Evans, R.R. 1991. Hydroelectric generating station extensions: Mattagami River hydraulic studies and impacts on fisheries habitat. Ontario Hydro Report No. 90367. Pagination unknown.

This document was not available for annotating.

Castiglione, C. Date unknown. Geographic information systems & decision support systems. United States Fish and Wildlife Service, Great Lakes Basin Ecosystem Team. 2 p. Available from <http://www.fws.gov/midwest/greatlakes/library/fact-gisdss-042804.pdf> [accessed 30 March 2006].

This was a short document about the uses of Geographic Information Systems (GIS) and Decision Support Systems (DSS). Reference was made to the creation of a lake sturgeon tributary database and its uses once complete.

Caswell, N.M., Peterson, D.L., Manny, B.A., and Kennedy, G.W. 2002. Spawning by Lake Sturgeon (*Acipenser fulvescens*) in the Detroit River. United States Environmental Protection Agency Great Lakes Grant Number: GL97505001-1. 21 p.

Lake sturgeon spawning in the Detroit River, Michigan was examined. Baited setlines were used to capture lake sturgeon. Bait consisted of dead round gobies (*Neogobius melanostomus*)

or cut squid. Total length, fork length, girth and total weight were measured. Each sturgeon was marked externally with a numbered floy tag or a numbered monel cattle ear tag, and internally with a PIT-tag (passive integrated transponder). A portion of the left marginal pectoral fin ray was removed for aging purposes. Ultrasonic transmitters were also implanted into twenty adult lake sturgeon. Egg collection mats were placed at two of three suspected spawning sites. At sites where eggs were collected, an underwater video camera was used to obtain images of bottom substrates. The capture and subsequent transmitter implantation of two ripe males led to the discovery of a new spawning site near Zug Island. Most of the sturgeon remained in a 10-12 km stretch of the river until April, when they moved to an area upstream near Zug Island. Substrates in this area consisted of coal cinders and scattered gravel deposits. Management implications are discussed. A detailed habitat analysis of known and suspected spawning sites was recommended.

Caswell, N.M., Peterson, D.L., Manny, B.A., and Kennedy, G.W. 2004. Spawning by lake sturgeon (*Acipenser fulvescens*) in the Detroit River. *J. Appl. Ichthyol.* **20**: 1-6.

The Detroit River historically had the largest lake sturgeon population in the Great Lakes, but little was known about their habitat use. To determine whether sturgeon spawned in the Detroit River, baited setlines were used to capture lake sturgeon in the spring and summer of 2000 and 2001. Ultrasonic transmitters were implanted in 10 adult fish each year to observe and assess their movements, and identify spawning sites. One spawning habitat was identified and verified by recovering sturgeon eggs deposited on egg collection mats anchored at the site. Spawning was not verified at several other potential spawning sites.

Cavender, T.M., and Bowen, J.E. 1994. Prehistoric lake sturgeon records from Woodland Period archaeological sites (300 BC - 1650 AD) adjacent to western Lake Erie, p. 15. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Cavender, T.M., and Davies, D. 1997. Status of the lake sturgeon population in Lake Erie, p. 565. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Chebanov, M. 1998. Conservation of sturgeon genetic diversity: enhancement and living gene banks, p. 163-173. *In* B. Harvey, C. Ross, D. Greer, and J. Carolsfeld (eds.) Action Before Extinction: An International Conference on Conservation of Fish Genetic Diversity. Vancouver, B.C., February 16-18, 1998.

Noted difficulties in conservation of sturgeon genetic diversity included a complicated population structure, late age at maturity, the length of time between spawning acts, and human impacts. A detailed examination of *Acipenser gueldenstaedti* and *A. stellatus* in the Sea of Azor was presented. The necessity for living gene banks and principles of collection were discussed.

Cherr, G.N., and Clark, W.H.Jr. 1985a. An egg envelope component induces the acrosome reaction in sturgeon *Acipenser transmontanus* sperm. *J. Exp. Zool.* **234**: 75-86.

The sperm of *Acipenser transmontanus* had an acrosome and an acrosomal process. Homologous egg water caused exocytosis and process formation in *A. transmontanus* sperm. Lake sturgeon were also tested and the egg water appeared to be species specific in its ability to induce the acrosomal reaction. The egg water could be fractionated on Cl 4B sepharose to obtain a specific reactive fraction. The component of egg water that induced the acrosomal reaction was characterized as a 66,000 dalton glycoprotein present in layer 3 of the egg envelope. The authors concluded that the soluble inducer was a smaller product of a 70,000 dalton molecule that was cleaved by a proteolytic enzyme. Evidence for this interpretation came from the absence of the 66,000 dalton molecule when inhibitors of trypsin were used in the egg water.

Cherr, G.N., and Clark, W.H., Jr. 1985b. Gamete interaction in the white sturgeon *Acipenser transmontanus*: a morphological and physiological review. *Environ. Biol. Fishes* **14**: 11-22.

This paper concentrated on gamete morphology, fertilization, acrosome reactions and other sperm-egg interactions of the white sturgeon with a brief discussion of cross-fertilization experiments with lake sturgeon. Lake and white sturgeon sperm were incubated with an isolated 70 KD glycoprotein component (precursor of the sperm inducer) of egg water, released by the egg envelope, to determine the specificity of this protein in activating sperm of the two species. Only white sturgeon sperm were activated and this species specificity was true for egg water as well. No lake sturgeon sperm adhered to white sturgeon eggs. At a low sperm concentration (10^3 sperm/egg) no fertilization occurred, but a high concentration (10^5 sperm/egg) resulted in 5% cross fertilization. This was attributed to the fact that a low proportion of the eggs undergo the acrosomal reaction when diluted in freshwater.

Chiasson, W.B., Noakes, D.L.G., and Beamish, F.W.H. 1997. Habitat, benthic prey, and distribution of juvenile lake sturgeon (*Acipenser fulvescens*) in northern Ontario rivers. *Can. J. Fish. Aquat. Sci.* **54**: 2866-2871.

The relative abundance of juvenile lake sturgeon and benthic macroinvertebrates were examined in the Mattagami and Groundhog rivers. The most common benthic taxa were *Ablabesmyia* sp. (Diptera) and *Hexagenia* sp. (Ephemeroptera). Benthic organisms were most numerous in substrate dominated by sand and clay. In addition, the highest concentration of juvenile lake sturgeon occurred in areas of sand and clay substrate. Lake sturgeon exclusively foraged on the benthos, particularly on taxa of Ephemeroptera, Diptera, and Trichoptera. Interestingly, *Hexagenia* was the only prey species to be found in greater density in the stomachs of sturgeon than in the benthos. The sturgeon tended to be more active at night, which may have been beneficial for foraging. In northern rivers the trophic status of juvenile lake sturgeon was marginalized by an impoverished food supply, partially caused by anthropogenic activity.

Chiotti, T. 2000. Stocked sturgeon in Cayuga Lake, p. 14-15. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from

<http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 30 March 2006].

Cholwek, G., Yule, D., Eitrem, M., Quinlan, H., and Doolittle, T. 2004. Mapping potential lake sturgeon habitat in the lower Bad River complex. United States Geological Survey. 21 p. Available from http://www.biosonicsinc.com/doc_library/docs/BadRiverFinalReport.pdf [accessed 30 March 2006].

The objectives of this study were to map and quantify tributary and nearshore habitat in the lower Bad River, to determine habitat use of juvenile lake sturgeon, and to provide habitat data that will aid in the control of sea lamprey. The habitat mapping was completed using acoustic techniques described in the report. The dominant substrate of the lower Bad River was clay at 45.82% (30.01 ha) of the total area (65.49 ha), followed by sand/clay at 32.07% (21.00 ha), and sand at 22.11% (14.48 ha). The dominant substrate of the open lake section was sand/silt at 75.74% (575.09 ha) of the total area (759.30 ha), followed by sand at 19.94% (151.40 ha), coarse sand/medium pebbles at 2.33% (17.73 ha), clay at 1.94% (14.70 ha), and cobble/boulder at 0.05% (0.38 ha).

Choudhury, A. 1997. Parasites of the lake sturgeon, *Acipenser fulvescens*: systematics and biogeography. Ph.D. Thesis, University of Manitoba, Winnipeg, Manitoba. xxiii + 457 p. Available from www.collectionscanada.ca/thesescanada/index-e.html [accessed 30 March 2006].

As evolutionary relics with a wide distribution in the northern hemisphere, sturgeons are ideal for studying the biogeography of host-parasite relationships. The aim of this study was to improve the knowledge of North American sturgeon parasites. It described *Diclybothrium atriatum* and *Spinitectus acipenseris* (synonyms for *Truttaedacnitis clitellarius* and *T. lebedevi*).

Choudhury, A., and Dick, T.A. 1991. Parasites of lake sturgeon, *Acipenser fulvescens* (Chondrostei: Acipenseridae), with special reference to the Coelenterate parasite, *Polypodium hydriforme*, in acipenseriform fishes: an annotated bibliography. *Can. Tech. Rep. Fish. Aquat. Sci.* **1772**: iv + 15 p.

All of the references from this document are included in the current bibliography.

Choudhury, A., and Dick, T.A. 1992. *Spinitectus acipenser* n. sp. (Nematoda: Cystidicolidae) from the lake sturgeon *Acipenser fulvescens* (Rafinesque) in Canada. *Syst. Parasitol.* **22**: 131-140.

Spinitectus acipenser, which closely resembles *S. gracilis*, was discovered for the first time in the muscular stomach of lake sturgeon from Manitoba and Saskatchewan. The spines of *S. acipenser* are larger and arranged differently than those of *S. gracilis*, the total body dimensions of adults are different, and this species has a ratio of 1:4 to 1:5 of esophagus to body length.

Choudhury, A., and Dick, T.A. 1993. Parasites of lake sturgeon, *Acipenser fulvescens* (Chondrostei: Acipenseridae), from central Canada. *J. Fish Biol.* **42**: 571-584.

Nineteen species of parasites were extracted from lake sturgeon sampled from the Saskatchewan, Nelson, Winnipeg, and Rainy rivers, with 12 being new host records. The most widely distributed and prevalent (70%) were *Crepidostomum auriculatum*, *Diclybothrium armatum*, *Spinitectus acipenser*, and *Truttaedacnitis clitellarius*. *Polypodium hydriforme* was found in only stage IV oocytes. The distribution of non-host specific parasites was determined by the type and relative abundance of food consumed. The parasites found in these lake sturgeon were more similar to those found in Eurasia than to those of North America. The presence of core parasite species appeared to predate geographic isolation. The benthic freshwater diet seemed to have changed the parasite community to one comprised of freshwater species and an association with freshwater habitats, reflected in the reproductive isolation of lake sturgeon. The establishment of the host-specific parasite *Spinitectus acipenser* also shaped the parasitic community.

Choudhury, A., and Dick, T.A. 1994. Natural anti-phosphorylcholine (PC) antibodies in lake sturgeon, *Acipenser fulvescens* Rafinesque, 1817 (Chondrostei: Acipenseridae). *Fish and Shellfish Immunology* **4**: 399-401.

Immunodiffusion experiments on lake sturgeon sera revealed a precipitation response against

homogenates of a natural tissue invasive helminth parasite, *Pomphorhynchus bulbocollis*. Strong precipitin bands were observed among *Anisakis*, *Aspergillus* SPS, PC-BSA, and *Trichinella* antigens when diffused against sturgeon sera, showing a common epitope in the carbohydrate component. Phosphorylcholine was the antigen determinant because of the formation of confluent precipitin bands when sturgeon sera and TEPC-15 were diffused concurrently against *Aspergillus* SPS, PC-BSA, and *Trichinella* antigens. Two of the three sera produced a precipitin band with PC-BSA. The use of 10^{-2} M phosphorylcholine chloride prevented precipitation reactions and provided additional evidence that the response of sturgeon was directed against PC. The precipitin bands disappeared after treatment of serum with 1 M 2-mercaptoethanol, suggesting that the precipitating antibodies were immunoglobulin type (IgM). This may be the first demonstration of anti-phosphorylcholine antibodies in fish. The mechanism of initiation and function required further investigation.

Choudhury, A., and Dick, T.A. 1996a. *Diclybothrium atriatum* n. sp. (Monogenea: Diclybothriidae) from North American acipenserid fishes with observations on *Diclybothrium armatum* and *Diclybothrium hammulatum*. *J. Parasitol.* **82**: 965-976.

Diclybothrium atriatum n. sp. was described from lake and shortnose sturgeon. The unique preovarial structure, named the ventral atrial organ, possessed a ventral orifice leading to a deep groove that widened internally and was bordered by densely staining granular bodies and more deeply situated glandular cells. Previous studies of *D. armatum* and other species of *Diclybothrium* revealed the presence of paired multichanneled sperm ducts that are characteristic of the Diclybothriidae (Bykhovskii and Gusev, 1950). The endemic nature of *D. atriatum* and specificity for lake and shortnose sturgeon suggested the speciation of this parasite followed the isolation of *Acipenser* L. spp. in central and eastern North America.

Choudhury, A., and Dick, T.A. 1996b. Observations on the morphology, systematics, and biogeography of the genus *Truttaedacnitis* (Nematoda: Cucullanidae). *J. Parasitol.* **82**: 977-987.

All species of *Truttaedacnitis* Petter were phylogenetically examined. *Cucullanus heterodonti* Johnston and Mawson was transferred to *Truttaedacnitis* because of the cephalic plates separated by sutures. The interrelationships among *Truttaedacnitis* spp. were analyzed using phylogenetic systematics. The anterior excretory pore supported the monophyly of *T. clitellarius* and *T. sphaerocephala* parasitizing sturgeons. The arrangement of cephalic plates suggested that *T. pybusae* Anderson and *T. truttae* formed a monophyletic group and supported the monophyly of *T. clitellarius* and *T. sphaerocephala*. The authors suggested that species of the families Acipenseridae, Salmonidae, and Petromyzontidae could be monophyletic. The systematics and biogeography of *Truttaedacnitis* suggested associations of this genus were primordial and relictual in nature, and likely determined by past continental and oceanic configurations, and vicariance and dispersal.

Choudhury, A., and Dick, T.A. 1998a. Systematics of the Deropristiidae Cable & Humminen, 1942 (Trematoda) and biogeographical associations with sturgeons (Osteichthyes: Acipenseridae). *Syst. Parasitol.* **41**: 21-39.

The biogeography and phylogenetics of eleven species belonging to the genera *Deropristis*, *Pristola*, *Skrjabinopsolus*, and *Cestrahelminis* were re-evaluated. *Skrjabinopsolus elongatus* Madhavi, *S. sanyaensis* Shen, *Deropristis paurosoma* Wang, and *Cestrahelminis Fischthal* did not belong to Deropristiidae. *D. paurosoma* was transferred to the resurrected genus *Opisthodioplomonorchis*. *S. armatus* Ivanov, *S. manteri*, *D. hispida*, *D. inflata*, and *P. sturionis* formed the Deropristiidae. The morphology and biology of the two species of *Skrjabinopsolus* were examined, and they were considered to be developing species. Analysis of Deropristiidae indicated that *Deropristis* and *Pristicola* may form a monophyletic group with *Skrjabinopsolus* as the sister taxon. Analysis of the biogeography of Deropristiidae revealed a possible origin linked to the formation of the North Atlantic basin, or marine/estuarine origins. A freshwater origin was traced to at least Cretaceous Laurasia, followed by a drift-vicariance separation and later association with North Atlantic drainages. It was concluded that deropristids originated and speciated within

Acipenseridae in the Atlantic region, with a host switch into Atlantic *Anguilla* spp.

Choudhury, A., and Dick, T.A. 1998b. The historical biogeography of sturgeons (Osteichthyes: Acipenseridae): a synthesis of phylogenetics, palaeontology and palaeogeography. *J. Biogeogr.* **25**: 623-640.

The authors argued that sturgeon reached a wide Laurasian distribution in the Cretaceous and Tertiary using freshwater and coastal waterways across land connections and continental margins. The fossil record indicated a significant degree of morphological stasis and an estuarine habit in addition to diadromy, an old and conserved life history trait. Phylogenetic relationships suggested that diversification was associated with fragmentation of biota, landmasses, and basins and by the late Tertiary, geological and climatic phenomena. Amphioceanic distributions of certain species and sister taxa were explained by coastal dispersal and vicariance caused by geologic and climatic changes in the Tertiary. Late Tertiary climatic and geologic phenomena were hypothesized as methods of vicariance and diversification of acipenserids. Although acipenserids are a geologically old group, their historical biogeography was best explained by more recent geological and climatic change.

Choudhury, A., and Dick, T.A. 1998c. Patterns and determinants of helminth communities in the Acipenseridae (Actinopterygii: Chondrostei), with special reference to the lake sturgeon, *Acipenser fulvescens*. *Can. J. Zool.* **76**: 330-349.

Occasionally dense but somewhat species rich isolationist gut helminth communities of lake sturgeon were observed. These parasite communities were predictable because of the high degree of host-specific helminths. This was also common among Siberian and Ponto-Caspian drainages and basins. Non-host specific parasites dominated helminth communities in Aral Sea drainages. Gut complexity and evolutionary age were poor predictors of community richness in sturgeons and other basal actinopterygians. The stochastic component of the gut helminth fauna was determined by shared trophic category and sympatry with other benthivorous fishes, specifically coregonines in Holarctic drainages and ostariophysans elsewhere. The authors cautioned that broad generalizations regarding

the factors shaping fish parasite communities were difficult to develop because of differences in biology and history of individual species and groups.

Choudhury, A., and Dick, T.A. 2001. Sturgeons (Chondrostei: Acipenseridae) and their metazoan parasites: patterns and processes in historical biogeography. *J. Biogeogr.* **28**: 1411-1439.

Phylogenetic and biogeographical evidence was used to assess hypotheses regarding the coevolutionary history of host-parasite associations and the origin of sturgeons. Relationships of parasites in various clades were analyzed using cladistics and interpreted in the context of vicariance events and dispersalist scenarios. Croizat's "biogeographical tracks" were used to characterize broadly compatible spatial patterns. The dominant track was Holarctic, involving northern and north-eastern Asian regions and North America, with evidence of a basal trans-Pacific track (found in *Crepidostomum auriculatum*, *Polypodium hydriforme*, *Truttaedacnitis*, *Capillospirura*, *Diclybothriidae*, *Amphiliina* and *Truttaedacnitis* and *Diclybothriidae*). Trans-Atlantic tracks appeared to be either independent of, or secondarily derived from, a Holarctic track (in *Bothrimonus* and *Truttaedacnitis sphaerocephala*). Evidence from parasites supported the theory that sister relationships existed between *Acipenser medirostris* and *A. mikadoi*, and between *A. fulvescens* and *A. brevirostrum*. Sturgeon dispersal and vicariance resulted in small, but widespread, highly distinct, monophyletic parasite lineages. These parasite clades continued to be associated with major and often discrete continental and oceanic formations, and occasionally with sturgeon species. The Cretaceous and early Tertiary Asian-American peninsula seemed to be important in the origin and early dispersal of parasites. This agreed with the hypotheses of the Asian-American peninsula as a key area in the early diversification of sturgeons and the acquisition of their parasite fauna. The parasite fauna also supported the hypothesis of a once continuous distribution of Nearctic and eastern Palearctic (Siberian) sturgeon that were disjointed by geological and climatic events. This resulted in the displacement of ancestral sturgeon populations in North America. These parasites also indicated a past connection with marine and brackish water conditions that pre-

dates the diversification of sturgeon, suggesting that ancestral acipenserids were diadromous.

Choudhury, A., Bruch, R., and Dick, T.A. 1996. Helminths and food habits of lake sturgeon *Acipenser fulvescens* from the Lake Winnebago system, Wisconsin. *Am. Midl. Nat.* **135**: 274-282.

Eight species of helminths were removed from 45 summer and 9 winter lake sturgeon adults and juveniles from Lake Winnebago. A total of 18 young-of-the-year (YOY) sturgeon from the Wolf River were infected. Both helminth communities were dominated by host specific parasites including *Crepidostomum auriculatum*, *Sklabinopsolus manteri*, *Capillospirura pseudoargementosa*, and *Truttaedacnitis clitellarius*. Chironomids were the most significant food item, indicating that there had been no change in benthos use of Lake Winnebago compared to past records. The host specific nematode, *Spinitectus acipenseris* was absent, likely due to the eutrophic environment of the lake and the absence of *Hexagenia* spp. Other host-specific endo-helminths seemed to be transmitted in deeper, downstream channels used as feeding areas by sturgeon two years and older. These results indicated that host specific helminths were not recruited until YOY juveniles moved to deeper, downstream channels to feed.

Choudhury, A., Dick, T.A., Holloway, H., and Ottinger, C. 1990. The lake sturgeon - *Acipenser fulvescens* in Canada: preliminary studies on parasitofauna and immunological parameters, p. 310-321. *In* Proc. 1990 N. D. Water Qual. Symp., March 20-21, Fargo, ND.

Twelve species of parasites were recovered from lake sturgeon in the waterways of Manitoba and Saskatchewan, seven of which were new host records for this species. A new form of *Spinitectus* was given a subspecies designation; *S. grackles acipenseris*. The study also reported, for the first time, a precipitation antibody response against an antigen common to parasites and fungi.

Christie, W.J. 1973. A review of the changes in the fish species composition of Lake Ontario. *Gr. Lakes Fish. Comm. Tech. Rep. No. 23*: 67 p. Available from www.glfc.org/pubs/TechReports/Tr23.pdf [accessed 29 March 2006].

An historical perspective of fisheries in Lake Ontario was discussed. Lake sturgeon were thought to have declined to commercially insignificant numbers by the turn of the 20th century. This decline was attributed mainly to overfishing, and secondarily to siltation, pollution, and habitat degradation. A chronology of declines and increases in populations of various fish species in Lake Ontario was outlined and discussed.

Christie, W.J. 1974. Changes in the fish species composition of the Great Lakes. *J. Fish. Res. Board Can.* **31**: 827-854.

Lake sturgeon were listed as being native to Lakes Ontario, Erie, Michigan, Huron, and Superior. Overfishing was cited as the cause of decline of lake sturgeon in the Great Lakes at the turn of the 20th century.

Christie, W.J., Spangler, G.R., Loftus, K.H., Hartman, W.L., Colby, P.J., Ross, M.A., and Talhelm, D.R. 1987. A perspective on Great Lakes fish community rehabilitation. *Can. J. Fish. Aquat. Sci.* **44**: 486-499.

Succession in the Great Lakes aquatic ecosystems was determined to be a repetition of maturation followed by seasonal, annual, or periodic setbacks, or enjuvenation events. A setback may be caused by any climatic or cultural factor that causes a flux in the energy-matter delivery to the system. The authors believed that the time period of rehabilitation was closely linked to the enjuvenation-maturation cycle and the life span and reproductive characteristics of the species. The sensitivity of the community to disturbance was related to what the authors termed, the "biomass storage" function of larger organisms in the system. Without trophic linkages providing biological feedback pathways from piscivorous species downwards, biomass capture of nutrient inputs by algae would be wasted as planktivore density limits secondary production. The direction of a fish community towards a specific species composition was dependent on the amount of external control applied to the system.

Chubbuck, D.A., and Evans R. 1982. Mattagami River preliminary environmental appraisal of hydroelectric development potential between Yellow Falls and Grand Rapids. Ontario Hydro, Toronto, ON. Pagination unknown.

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Ciereszko, A., and Dabrowski, K. 1995. Spectrophotometric measurement of aspartate aminotransferase activity in mammalian and fish semen. *Anim. Reprod. Sci.* **38**: 167-176.

The Karman assay of aminotransferase activity, modified by the International Federation of Clinical Chemistry and the authors, was more accurate in semen analysis than previous methods. Although the assay system did not work for neat bull seminal plasma, enzyme activity could be measured accurately in diluted samples. Slight inhibition of enzyme activity was often seen at 240 nM of L-aspartate. Therefore, a lower concentration of this substrate should be used in the future.

Ciereszko, A., Dabrowski, K., Froschauer, J., and Wolfe, T.D. 2006. Cryopreservation of semen from lake sturgeon. *Trans. Am. Fish. Soc.* **135**: 232-240.

Lake sturgeon semen was successfully cryopreserved using methanol as the cryoprotectant. Eggs remained viable after 8-12 hours in transport provided their initial quality was high. Cryopreservation caused some damage to sperm DNA, and resulted in an 87% decrease in fertilization rates of prehatched larvae compared to fresh semen.

Ciereszko, A., Dabrowski, K., Lin, F., and Doroshov, S.I. 1994. Identification of trypsin-like activity in sturgeon spermatozoa. *J. Exp. Zool.* **268**: 486-491.

Trypsin-like activity was present in spermatozoa of lake sturgeon and white sturgeon, corresponding to the presence of acrosomes and acrosome reactions in spermatozoa of these fish. Higher activity occurred at pH of 8.5 and 9.0 than at 8.0. Trypsin-like activity was not affected by 10 nM KCL and 100 nM NaCl. Calcium ions inhibited activity at 10 and 50 nM. Similar observations were noted in neat semen and washed sperm suspension.

Ciereszko, A., Dabrowski, K., Mins, S.D., and Glogowski, J. 2000. Characteristics of sperm acrosin-like activity of paddlefish (*Polyodon spathula* Walbaum). *Comp. Biochem. Physiol. Part B* **125**: 197-203.

This study characterized acrosin-like activity of cryopreserved sperm of paddlefish (*Polyodon spathula*), and subsequently tested and compare it to that of lake sturgeon and bull spermatozoa. Acrosin-like activity was 79% higher in whole semen than spermatozoa, with the highest activity at a pH 8.0 and 8.5. Triton X-100, zinc ions, and 4'-acetamidophenyl 4-guanidinobenzoate (AGB) inhibited activity. Amidase activity was hampered by N- α -p-tosyl-L-lysine chloromethyl ketone (TLCK) and N-tosyl-L-phenylalanine chloromethyl ketone (TPCK). TLCK, at concentrations of 0.1 and 1.0 mM, caused a significant decrease in activity of 19% and 61%, respectively. TPCK inhibited activity by 19% at a concentration of 1.0 mM. After acidification and a 60 minute incubation period of sperm suspensions at 4°C, just 4% of the activity was preserved. This was also observed in lake sturgeon sperm, but not in bull sperm. These results showed that trypsin-like activity in Acipenseridae more closely resembled that of fish.

Ciereszko, A., Dabrowski, K., and Ochkur, S.I. 1996. Characterization of acrosin-like activity of lake sturgeon (*Acipenser fulvescens*) spermatozoa. *Molecular Reproduction and Development* **45**: 72-77.

Acrosin-like activity of sturgeon sperm could be preserved when the sperm was frozen on dry ice with 0.6 M sucrose-10% dimethylsulfoxide (DMSO) extender (sperm:extender ratio 1:3), and then stored in liquid nitrogen. Activity decreased through time, and after 13 days an 88% decline was noted. On the other hand, acrosin-like activity increased with temperature from 10°C to 30°C, but was inactivated at 40°C to about 40% of the optimum. Mg^{2+} did not affect activity while Zn^{2+} reduced activity by 30% and 75% in the presence of 0.1 nM and 1.0 nM respectively. Maximum velocity of substrate hydrolysis occurred at 2 mM N- α -benzoyl-DL-arginine p-nitroanilide hydrochloride (BAPNA). Acrosin-like activity was also inhibited by 4'-acetamidophenyl 4-guanidinobenzoate (AGB), a mammalian acrosin inhibitor. Acrosin-like activity was negatively correlated with anti-proteinase activity of seminal plasma. Sturgeon acrosin-like activity had many properties in common with mammalian acrosin, but also had unique properties that may represent adaptations to external fertilization.

Ciereszko, A., Ochkur, S.I., and Dabrowski, K. 1994. Characterization of trypsin-like activity of lake sturgeon (*Acipenser fulvescens*) spermatozoa, p. 8. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Ciereszko, A., Toth, G.P., Christ, S.A., and Dabrowski, K. 1994. Computer-assisted analysis of sperm motility in the lake sturgeon (*Acipenser fulvescens*): activation and inhibition study, p. 8-9. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Ciereszko, A., Toth, G.P., Christ, S.A., and Dabrowski, K. 1996. Effect of cryopreservation and theophylline on motility characteristics of lake sturgeon (*Acipenser fulvescens*) spermatozoa. *Theriogenology* **45**: 665-672.

Motility and acrosin-like activity were recorded and measured at 0 and 5 minute postactivation by computer-assisted motility analysis (CASA). Cryopreservation caused a decrease in the percentage of motile spermatozoa while other parameters of sperm motion did not change. Reductions in straight line velocity observed with fresh and cryopreserved spermatozoa and in linearity with cryopreserved spermatozoa 5 minute postactivation were not observed with 5 mM theophylline. Frozen-thawed spermatozoa retained acrosin-like activity and it correlated with the percentage of post-thaw motility ($r=0.95$ and $r=0.9$, $P<0.05$, for 0 and 5 minute postactivation time, respectively).

City of Norway. 2002. Final application for a new license for a major water power project more than 5 Megawatts - existing dam, Sturgeon Falls hydroelectric project FERC project no. 2720. City of Norway, MI. 8 p.

This document was not available for annotating.

Classen, T.E.A. 1949. Age and rate of growth of the sturgeon. Age at sexual maturity. Wisconsin Conservation Department, Madison, Wisconsin. 20 p. + figures.

Methods used to age sturgeon were reviewed. The relationship between the annual growth of scales or bones and the total length of the fish

were presented in relation to fish age determination. The author collected the marginalia of the pectoral fin for ageing sturgeon. Sections about 0.5 mm in thickness were made with a hack saw, polished with a very fine file, and then mounted in Canadian balsam. Aging structures were collected from spawning fish; very few young fish were examined. Amur fish grew more slowly than fish from southern Europe. There was little correlation between age and length. The use of photography to record the sections appeared to work, and illustrations were used to show clearly how annuli were determined. Males reached sexual maturity at a length of about 120 cm and age of 10-11 years. Females generally reached sexual maturity at 15 and occasionally at 13 years. There was considerable variation in size relative to age. Female sturgeon grew less in the year of spawning than in the year they remained at sea. The author believed that the sturgeon spawn in alternate years.

Clayton, T. 2001. The 2000 harvest of lake sturgeon in Alberta. Alberta Sustainable Development, Fish and Wildlife Service. Lethbridge, Alberta. vii + 34 p.

This report summarized the results of the 2000/2001 angling survey of sturgeon license holders in Alberta. This was the 33rd year the survey was carried out. Two hundred and sixty-six surveys were sent out and 230 were delivered (36 undelivered). The response rate was 57% (131 respondents). Of the 164 sturgeon reported caught, 11 (7%) were harvested. This was an increase of 12% from the reported catches of 1999/2000. On average 4.7 days or 32.7 hours were spent per angler fishing for sturgeon. The average time it took to catch one sturgeon was 15.6 hours. Forty-one percent of respondents caught at least one sturgeon. The largest sturgeon weighed 27 kg while the average weight was 8.3 kg. All fishing occurred in the South Saskatchewan, North Saskatchewan and Red Deer river systems.

Clayton, T.B. 2002. The 2001 harvest of lake sturgeon in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB. vii + 31 p.

This report summarized the results of the 2001/2002 angling survey of sturgeon license holders in Alberta. This was the 34th year the survey was carried out. Some 252 sturgeon

licenses were purchased and 230 surveys were delivered (22 were undelivered). The response rate was 59% (136 respondents). Of the 242 sturgeon reported caught, 7 (2%) were harvested. This was an increase of 48% from the reported catches of 2000/2001. On average 4.4 days or 27.4 hours were spent per angler fishing for sturgeon. The average time it took to catch one sturgeon was 12.8 hours. Some 37% of respondents caught at least one sturgeon. The largest sturgeon weighed 33 kg while the average weight was 7.7 kg. All fishing occurred in the South and North Saskatchewan river systems.

Clayton, T.B. 2003. The 2002 harvest of lake sturgeon in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB. vii + 31 p.

This report summarized the results of the 2002/2003 angling survey of sturgeon license holders in Alberta. This was the 35th year the survey was carried out. Some 276 sturgeon licenses were purchased and 236 surveys were delivered (40 were undelivered). The response rate was 59% (138 respondents). Of 168 sturgeon reported caught, 5 (3%) were harvested. This was a decrease of 31% from the reported catches of 2001/2002. On average 3.9 days or 22.7 hours were spent per angler fishing for sturgeon. The average time it took to catch one sturgeon was 11 hours. Fifty percent of respondents caught at least one sturgeon. The largest sturgeon weighed 41 kg while the average weight was 7.4 kg. All fishing occurred in the South and North Saskatchewan river systems.

Clayton, T.B. 2004. The 2003 harvest of lake sturgeon in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB. vii + 31 p.

This report summarized the results of the 2003/2004 angling survey of sturgeon license holders in Alberta. This was the 36th year the survey was carried out, and the last year of legal sturgeon harvest in Alberta. Two hundred and seventy-eight sturgeon licenses were purchased and 249 surveys were delivered (29 were undelivered). The response rate was 56% (146 respondents). Of 244 sturgeon reported caught, 5 (2%) were harvested. This was an increase of 45% from the reported catches of 2002/2003. On average 4.1 days or 21.4 hours

were spent per angler fishing for sturgeon. The average time it took to catch one sturgeon was 9 hours. Fifty-four percent of respondents caught at least one sturgeon. The largest sturgeon weighed 27 kg while the average weight was 8.6 kg. All fishing occurred in the South and North Saskatchewan river systems.

Clemens, W.A., Dymond, J.R., Bigelow, N.K., Adamstone, F.B., and Harkness, W.J.K. 1923. The food of Lake Nipigon fishes. Univ. Toronto Stud. Biol. Ser. Publ. Ont. Fish. Res. Lab. **16**: 173-188.

A total of 12 lake sturgeon captured on June 23, 24, July 9, 12, and August 26 were examined for intestinal contents. Contents included ephemeropterid nymphs which made up 98% of the food for sturgeon captured in August, chironomid larvae which constituted 65% of the gut contents of one sturgeon of June 24, molluscs which comprised 50-100% of five samples, and fish remains which made up 20-98% of the diet of four fish. Miscellaneous finds included trichopterans, gammarids, odonate nymphs, algae and vascular plant tissues, cyclopoid copepods, diatoms and cladocerans.

Clements, G. 1996. The 1995 harvest of lake sturgeon in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB. 17 p.

Questionnaires were mailed to sturgeon anglers who purchased an Alberta license in 1995. A total of 295 licenses were reported sold and 210 questionnaires were returned. However, private license sellers did not report all license sales until after the questionnaire was mailed, and there were actually 337 licenses sold. Sixty-three percent of respondents fished for sturgeon and 67% caught at least one. Of the 766 sturgeon caught in 1995 an estimated 51 (6%) were kept. The average weight was 7.0 kg, with the largest weighing 41 kg. Most of the sturgeon were caught in the South Saskatchewan River (97%). Only 2% were caught in the North Saskatchewan River and 1% in the Oldman River. The best location for sturgeon fishing on the South Saskatchewan River was the Rattlesnake Hole (0.49/hour), where 200 sturgeon were caught. The Medicine Hat and Grand Forks areas of the South Saskatchewan River were also good locations, with 114 and 123 sturgeon being caught, respectively. Results were compared to those of previous years.

Cochran, P.A. 1995. Lake sturgeon (*Acipenser fulvescens*) in the lower Fox River, Wisconsin. Sturgeon Quarterly **3**: 8-9.

Lake sturgeon were observed in the Fox River below the DePere dam during the servicing of a sea lamprey assessment trap. In this area the tailwaters were less than 1.5 meters, with a rocky substrate.

Cochran, P.A., and Kinziger, A.P. 1997. *Hexagenia bilineata* (Ephemeroptera: Ephemeridae) persists at low levels of abundance in the lower Fox River, Wisconsin. Gt. Lakes Entomol. **30**: 89-92.

Burrowing mayflies were first noted near the DePere Dam on the Fox River in 1991, with adults being seen in small numbers since. Sea lampreys and lake sturgeon have also been noted in the Fox River. This served as an indication that environmental conditions were improving, although it was not confirmed that any of the three had established populations that could successfully reproduce in the river.

Cochran, P.A., Lyons, J., and Gehl, M.R. 2003. Parasitic attachments by overwintering silver lampreys, *Ichthyomyzon unicuspis*, and chestnut lampreys, *Ichthyomyzon castaneus*. Environ. Biol. Fishes **68**: 65-71.

Lake sturgeon harvested through the ice, by spearing, in the Lake Winnebago system were observed bearing silver lampreys or fresh lamprey wounds. Sturgeon with lamprey marks were significantly larger than sturgeon without. Silver lampreys that were collected from paddlefish (*Polyodon spathula*) from the Wisconsin River in March were not significantly larger than those collected in late October, but were significantly heavier, suggesting they had been feeding. Northern pike, *Esox lucius*, and flathead catfish, *Pylodictus olivaris*, had been observed in the winter bearing silver or chestnut lampreys. Lampreys attached to hosts in the winter benefited from the host mobility and ability to avoid potentially dangerous circumstances, although their energy and nutrient intake was reduced.

Colcleugh, F.W. 1901. p. 145-149. In Thirty-third annual report of the Department of Marine and Fisheries. Sessional Paper No. **22**.

The 1899 season was not favorable for fishing in Lake Winnipeg. Sturgeon were highly sought after, resulting in an increased number of licenses to fish for them, but the sturgeon catch decreased compared to the previous year. Fishing during the last half of the season was particularly poor, with many fishermen making less than half their usual wages. Surveyors of the Berens River also reported lower sturgeon catches, and expressed concern about the future state of sturgeon in the river. Some 444,787 pounds of sturgeon were caught from all districts in Manitoba, valued at \$26,687 in 1899.

Collette, C. 1989. The other anadromous fish. Northwest Energy News **March/April**: 27-29.

The focus of this article was on white sturgeon in the Columbia River, Idaho. A general description of sturgeon and a brief discussion of their life history were presented. Ongoing research and goals of the Columbia River Basin Fish and Wildlife Program were discussed.

Collins, J.J. 1988. Changes in the North Channel fish community, with emphasis on pink salmon (*Oncorhynchus gorbuscha* Walbaum). *Hydrobiologia* **163**: 195-213.

This account of the community dynamics of the North Channel, a discrete basin differing qualitatively from other basins of Lake Huron, emphasized pink salmon. However, a graphic description of the history of various fisheries provided information on lake sturgeon. The lake sturgeon fishery was established after 1880 with production rising to over 100 tonnes in 1885 and declining quite rapidly thereafter to negligible quantities at the turn of the century. Insignificant quantities continued to be harvested until the fishery was closed around 1910. The principle fishing gear used was gillnets.

Committee on the Status of Endangered Wildlife in Canada. 2001. Canadian species at risk. Environment Canada, Canadian Wildlife Service. Pagination unknown.

Lake sturgeon (*Acipenser fulvescens*) were listed as not at risk (NAR), while green sturgeon (*Acipenser medirostris*), shortnose sturgeon (*Acipenser brevirostrum*), and white sturgeon (*Acipenser transmontanus*) were listed as species of special concern.

Committee on the Status of Endangered Wildlife in Canada. 2005. COSEWIC species assessments (short version), May 2005. COSEWIC. 4 p. Available from http://www.cosewic.gc.ca/rpts/Short_Species_Assessment_e.pdf [accessed 30 March 2006].

This document consisted of a table summarizing COSEWIC species assessments. The status, taxonomic group, common name and population, previous status and date of last assessment, and range of occurrence in Canada were given. The western populations (AB, SK, MB) of lake sturgeon were listed as "Endangered".

Conroy, N., and Keller, W. 1971. Biological evaluation of the Kapuskasing River, north of the town of Kapuskasing. Ontario Ministry of the Environment, Sudbury, ON. Pagination unknown.

This document was not available for annotating.

Cook, F.A. 1959. Sturgeon family, Acipenseridae, p. 49-51. *In* Freshwater fishes in Mississippi. Mississippi Game and Fish Commission.

Four species of acipenserids, including the lake sturgeon, were included in a fairly detailed key. This was followed by brief notes for individual species. The lake sturgeon population rapidly declined after 1895. Historical weights of lake sturgeon were 100 pounds or more, although 40 pound fish were more likely. A report of a 35 pound ripe female sturgeon in the Upper Mississippi in 1950 was included.

Cook, W.J. 1987. Enforcement implications for management of lake sturgeon (*Acipenser fulvescens*) in Ontario, p. 95-96. *In* C. H. Olver (ed.) Proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23.

Problems enforcing regulations for sturgeon fishing were discussed. These included a lack of knowledge about fishing regulations, licensing, fishing gear, and audit procedures. Recommendations to improve current enforcement practices included a communications plan between managers and the public, the development of a data base for sturgeon fisheries and enforcement plans developed on a regional basis.

Cooper, A.R. 1915. Trematodes from marine and freshwater fishes, including one species of ectoparasitic turbellarian. *Trans. R. Soc. Can.* **4**: 181-205.

As far as the author was aware, *Acrodactyla petalosa*, whose original description was unavailable, had been reported from lake sturgeon only. A footnote on p. 195 provided a brief description and comments on *A. petalosa*. Numerous specimens of this species were recovered from lake sturgeon from the St. Lawrence River, near Iroquois, Ontario, and examined. It confirms Stafford's description of the species. The position of the genital opening, the size of the cirrus-sac, and the arrangement and size of the oral papillae were considered distinctive of the species. A typical specimen measured 2.44 x 0.61 mm (maximum width), the oral sucker 0.38 x 0.33 mm, and ventral sucker 0.27 mm in diameter.

Cooper, E.L. 1957. What kind of sturgeon is it? *Wis. Conserv. Bull.* **23**: 31.

This short note distinguished between two of Wisconsin's common sturgeon, the lake sturgeon and the shovelnose sturgeon. The distinguishing features included the presence of a filament from the upper lobe of the caudal fin and a tail completely covered by scutes in the shovelnose sturgeon. The shovelnose also occurred only in the Mississippi drainage in Wisconsin but not in the Great Lakes or their tributaries. Lake sturgeon were abundant in Lake Winnebago, their traditional location in Wisconsin.

Copeland, J. 1970. Experimental sturgeon rearing, 1970. Michigan Department of Natural Resources. Wolf Lake State Fish Hatchery, Kalamazoo, Michigan. 3 p.

This was a report on sturgeon culture at the Wolf Lake Fish Hatchery. Fertilized eggs were transported on ice to the hatchery. Fifty thousand eggs were collected but only 638 hatched. Fungal infections on eggs seemed to be the main cause of mortality and treatment of eggs against fungi was suggested. Fry were placed in a 55 gallon aquarium with fine gravel on the bottom and it was suggested that fish be reared in troughs without gravel in the future. Initially, they were fed brine shrimp and as the fish became bigger were fed chironomids, tubificids, and finally annelids. Three inch fry

were placed in ponds but no fish were recovered after 135 days.

Courtemanche, M. 2003. *Pratiques halieutiques à la station 4 de la Pointe-du-Buisson (BhF1-1) au Sylvicole Moyen Tardif (920-940 AD)*. M.Sc. Thesis, Department of Anthropology, Université Laval, Saint-Foye, Québec. Pagination unknown.

This document was not available for annotating.

Coutant, C.C. 2004. A riparian habitat hypothesis for successful reproduction of white sturgeon. *Rev. Fish. Sci.* **12**: 23-73.

A new hypothesis was presented for the cause of low recruitment in white sturgeon populations, as was a detailed examination of the species' spawning and early development. The populations on which the new hypothesis was based were from the Columbia River basin and lower Fraser and Sacramento rivers. Each of the study areas and populations were discussed. The riparian habitat hypothesis contends that "submerged riparian habitat during seasonal high water is needed for early development" (pg. 23). Management plans should therefore include the rehabilitation of riparian zones and provide for high water flows during spawning to enhance natural recruitment. Evidence supporting this hypothesis was presented in detail and alternative hypotheses were examined. The implications of this hypothesis for management plans were discussed.

Cox, D. 2004. History of fishing regulation development on the Menominee Indian reservation. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Lake sturgeon played an important role in the lives of the Menominee people. The tribe was moved to the current reservation in 1854. Since then, fishing regulations have had a varied impact on the Menominee people that live on and off the reservation. In the past, the tribe was restricted from harvesting lake sturgeon. More recently, the tribe has enforced regulations to manage, harvest, and protect the fish. Traditional ecological knowledge and governmental procedures played a vital role in regulations governing the harvest of this species.

Craig, J., Jenkins, J., and Nichols, J. 2004. Baseline hematology and DNA content data from lake sturgeon from lower Lake Huron. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Baseline data on morphology and aspects of blood were examined from sturgeon sampled from lower Lake Huron. Thirty fish were collected in 2003. Measurements included total length (833-1,783 mm), fork length (739-1,635 mm), body girth (364-667 mm), and weight (3.5 - 32.2 kg). Relative condition factor was calculated to range from 0.747 to 1.170, and the age of the fish from 5 to 32 years. Blood from the caudal vein was analyzed for DNA integrity by flow cytometry and differential blood cell counts by light microscopy. Two individuals had a subpopulation of nuclei with high DNA content. Leukocytes made up $8.1\% \pm 0.8\%$ of the total blood cell count.

Craig, J.M., Thomas, M.V., and Nichols, J.S. 2004. Length-weight relationship and a relative condition factor equation for lake sturgeon from the St. Clair River system (Michigan, USA). *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

A standard equation for the condition (Kn) of lake sturgeon in the St. Clair River system was established to facilitate data comparison and communication among researchers and agencies. Total length (mm) and weight (kg) were measured for 1,074 lake sturgeon collected from the St. Clair River system from May-September of 1997-2002. Least squares regression of $\log 10TL \times \log 10W$ produced the equation $\log W = 3.365\log TL - 9.320$. Using the slope and y-intercept from the exponential form of the equation, the relative condition factor for lake sturgeon from the St. Clair system was calculated as $Kn = W / [(4.786 \times 10^{-10})(TL^{3.365})]$.

Cross, F.B. 1967. Lake sturgeon, *Acipenser fulvescens* Rafinesque, p. 33-34. *In* Handbook of Fishes of Kansas. University of Kansas Museum of Natural History Misc. Publ. No. 45.

The record of Snow (1875) of lake sturgeon in Kansas was regarded as valid although there may be reason to doubt it. Since 1952, the author had seen photographs of two lake sturgeon caught in the state.

Crossman, E.J. 1976. Lake Sturgeon - *Acipenser fulvescens*, p. 4-5, 54. *In* Quetico Fishes. Royal Ontario Museum, Toronto, Ontario.

This species was considered among the largest in the park and known only from four lakes, or 2.1% of the locations.

Crossman, E.J., and Van Meter, H.D. 1979. Annotated list of the fishes of the Lake Ontario watershed. Gr. Lakes Fish. Comm. Tech. Rep. 36: 25 p. Available from www.glfc.org/pubs/TechReports/Tr36.pdf [accessed 29 March 2006].

The lake sturgeon was once abundant in Lake Ontario, but stock depletion occurred by 1900. It was doubtful whether the lake supported a spawning population.

Cuerrier, J.-P. 1947. Quelques indications sur la taille de maturité, la fréquence des pontes et la saison de ponts de l'Esturgeon de lac. *Ann. ACFAS (Assoc. Can. Fr. Av. Sci.)* 13: 100.

Observations were made on 527 commercially captured lake sturgeon in Lake Saint-Pierre between June and September of 1945. The size of sampled fish reportedly ranged from 60-180 mm (this is probably a misprint and should be 'cm') and weighed between 3-101 pounds. The author described the gonads and stages of female gonad development and discussed size at maturity, and the frequency and season of spawning. The author applied this data to legislation related to sturgeon fishing.

Cuerrier, J.-P. 1949a. L'esturgeon de lac, age-croissance-maturité. *Chasse et Pêche* 1: 26.

Age was determined by sectioning a pectoral fin, placing it in glycerine, and counting the growth rings. The age at maturity for males was determined to be 14 years and for females, 25 years.

Cuerrier, J.-P. 1949b. Observations sur l'esturgeon de lac (*Acipenser fulvescens* Raf.) dans la région du lac Saint-Pierre au cours de la période du frai. These Manuscrit. Université de Montréal, Montréal, Québec. 164 p.

Results from a biological investigation of lake sturgeon from the Saint-François River and

Saint-Pierre Lake conducted between April and June 1947/48 were presented. Variables measured on each fish were length, weight, sex, maturity, head length, circumference, gonad weight and dressed weight. Conclusions from the study included that fish moved up the Saint-François River to spawn, spawning occurred between May 2 and 15 while water temperature ranged from 12-16°C, and mature fish were captured in Saint-Pierre up to the end of June apparently searching for spawning grounds upstream of the lake. The percentage of males that made up the catches was higher than females, 71% and 25%, respectively. There were twice as many mature males as mature females. During spawning, females released their eggs over a short period of time while males appeared to slowly release milt over a longer period of time, peaking at the height of spawning. During the spawning season, juvenile and reproducing fish fed on molluscs, crustaceans, larval insects, and lake sturgeon eggs. Male lake sturgeon from both sites matured at smaller length and age (762 mm, 14 years) than females (1,168 mm, 25 years). Mature females had a larger condition factor than mature males, and immature male and female fish had condition factors similar to mature males. The gonadosomatic index of mature females before and after spawning was 21.5% and 4.1%, respectively. The gonadosomatic index of males before spawning was 8%, and the values for males and females after spawning were similar (2.2%). Egg diameter of mature females varied between 2.8 and 3.1 mm with an average of 2.88 mm. Conservation measures should include no fishing of lake sturgeon during the spawning season and regulations on gill net mesh size in order to protect juvenile fish.

Cuerrier, J.-P. 1951. The use of pectoral fin rays for determining age of sturgeon and other species of fish. *Can. Fish Cult.* 11: 10-18.

Bibliographical material on sturgeon aging was presented and the technique for aging them by sectioning the marginal pectoral fin ray was described. The first ray or first few rays were removed from the pectoral fin at the articulation with the basal cartilaginous piece and dried. Thin 0.3-0.5 mm sections were made about 1/4 inch from the base of the fin-ray with a jewelers saw. The sections were mounted temporarily in a drop of glycerine which rendered the annuli visible. Wide opaque zones alternated with

narrow clear zones, the former corresponding to summer growth and the latter to winter growth. The summer bands were thick and opaque, indicating abundant deposition of connective tissue that was subsequently converted into bone during the active metabolic activity and feeding phase. The winter growth ring signified the period of metabolic inactivity, when only a small amount of connective tissue deposition and conversion to bone occurred.

Cuerrier, J.-P. 1962. Inventaire biologique des poissons et des pêcheries de la région du Lac Saint-Pierre. *Nat. Can. (Qué.)* 89: 193-213.

A survey of fish from the Lac Saint-Pierre region from 1944 to 1946 was discussed. A detailed map of the Saint-Pierre region was included in the text. Fish were divided into the following six groups: the most important commercial species (lake sturgeon were in this group), secondary commercial species, the most important sport fish species, sport fish of secondary importance, and species that were predaceous or parasitic. The total catches for the years 1945 and 1946 were 266,190 and 324,610 pounds, respectively. Data collected for lake sturgeon were reported and included the location of populations, numbers, and their movements. A table listed the commercial catch of lake sturgeon by month for the years 1944 to 1946. The catch ranged from 32,612 pounds in 1944 to 44,300 pounds (value \$15,000) in 1946. Sturgeon were caught with lines and seines and separated into those less than 12 pounds and those greater than 12 pounds. During the winter fishery sturgeon were caught in whitefish nets. There was likely some illegal fishing of sturgeon in May of 1944-46. Figures were included illustrating the proportion of the catch that was under 12 pounds. The June catch had the highest proportion of small fish. From 690 specimens sampled, the length ranged from 22 to 67 inches and 3 to 101 pounds. Of 534 examined for sex, 51% were male and 49% female. First maturation for males occurred at 15-20 pounds, and for females at about 30 pounds. Stomachs were examined from 200 specimens and food items included amphipods, larval of diptera, trichoptera, and the small gastropod *Bullimus tentaculatus* (present in most of the stomachs examined).

Cuerrier, J.-P. 1966. L'esturgeon de lac *Acipenser fulvescens* Raf. de la région du Lac St. Pierre au cours de la période du frai. *Nat. Can. (Qué.)* 93: 279-334.

Data were obtained from commercial gill netting operations in the Lake St. Pierre region in 1947 and 1948. Males reached sexual maturity at approximately 14 years of age, and females at approximately 25 years. It was found that the coefficient of condition varied by sex and development of the gonads. Ovaries of mature females represented 21.5% of total body weight, while the testes of mature males represented 8%. Data on relative fecundity and the number of eggs produced by sturgeon size were also presented.

Cuerrier, J.-P., and Roussow, G. 1951. Age and growth of lake sturgeon from Lake St. Francis, St. Lawrence River. Report on material collected in 1947. *Can. Fish Cult.* **10**: 17-29.

This paper summarized the data collected in Lake St. Francis during 1947. A total of 342 sturgeon were examined, of which 138 were killed and sold on the local market. Two hundred and four were tagged and released. Long term statistics revealed that the Lake St. Francis sturgeon fishery had been quite prosperous, with annual catches of 14,000 to 35,400 (average of 27,040 pounds) between 1923 and 1933. From 1933 to 1943 the average annual catch was 13,800 pounds. The decline of the fishery was discussed and, while popular opinion considered dam construction to be the major cause, the authors suggested that fishing methods may have contributed to the decline. Interesting information was included, such as the legal size of 28 inches for sturgeon, as specified in the fishing regulations of the Province of Québec. By contrast, the Ontario administered portion of Lake St. Francis had a size limit of 36 inches, while elsewhere in Ontario the size limit was 42 inches. The Québec fishery also used mesh sizes that offered no protection against small sturgeon as indicated by size frequency plots of length and weights. Lake St. Francis sturgeon grew faster than Lake Nipigon sturgeon in both length and weight. The coefficient of condition for fork lengths of Lake St. Francis sturgeon was 2.67 while that of Lake St. Peter was 3.15. These coefficients were calculated using the equation $K(FL) = (P \times 10^4)/L^3$, where $K(FL)$ is the coefficient of condition calculated from fork length measurements, P is the weight in pounds, and L is fork length in inches. Only three mature fish were caught, two males 15 and 21 years and a female 23 years old. None were in spawning condition.

Curatolo, M. 2003. Returnin' sturgeon. *New York State Conservationist* **December**: 10-11.

The success of lake sturgeon recovery efforts in the Oswegatchie River, New York was discussed. The biology of the lake sturgeon was briefly examined.

Cusson, M.P. Date unknown. King of fishes and fish of kings. Ontario Dept. Lands and Forests, Kapuskasing District, MS. Rep. 7 p.

This document examined the history of lake sturgeon in North America, with particular reference to Ontario. Their distribution, biology, ecology, life history and response to human impacts were discussed.

Czeskleba, D.G., Avelallemant, S., and Thuemler, T.F. 1985. Artificial spawning and rearing of lake sturgeon, *Acipenser fulvescens*, in Wild Rose State Fish Hatchery, Wisconsin, 1982-1983. *Environ. Biol. Fishes* **14**: 79-85.

This paper documented the efforts of the Wisconsin Department of Natural Resources, under the supervision of the authors, to obtain and culture lake sturgeon eggs at the Wild Rose State Fish Hatchery. Lake sturgeon eggs and milt were collected from the Wolf River sturgeon population in the spring of 1982 and 1983, fertilized and hatched, and the larvae reared in the state hatchery. The overall hatching success was 59.2% with mortalities caused by fungal infection. A temperature of 13°C resulted in greater hatching success and fewer fungus problems, compared to incubation at 16°C. Formalin treatment reduced but did not eliminate fungal problems. Growth of larvae during the first 30 days post hatching (the first 10 days were devoted to endogenous yolk feeding) was comparable to wild fish from the Wolf River. Growth of hatchery larvae was further stimulated by the addition of live food (*Daphnia*) up to day 50. Thereafter, hatchery reared larvae grew at a lower rate, reaching 101.4 mm by day 123, compared to about 200 mm (from graph) for wild juveniles. Lake sturgeon larvae did not accept Oregon Moist Pellet as an artificial diet and died by day 29 under that regime. In all cases live food was preferred over commercial diets. Frozen food (*Daphnia* and brine shrimp) was a marginal diet and it was recommended that lake sturgeon larvae be fed a variety of live food initially and gradually weaned to other artificial diets to prevent imprinting on a particular diet.

Sturgeon larvae did not contract any diseases during weekly treatments with chloramine-T-hydrate. The numbers of larvae stocked into various waterways as part of the program were also provided.

Czesny, S., Dabrowski, K., Christensen, J.E., Van Eenennaam, J., and Doroshov, S. 2000. Discrimination of wild and domestic origin of sturgeon ova based on lipids and fatty acid analysis. *Aquaculture* **189**: 145-153.

Fatty acid profiles of neutral and phospholipid fractions of three populations of white sturgeon (two domestic and one wild) and one population of wild sturgeon were studied to determine if different origins of sturgeon eggs could be delineated based on biochemical composition. Palmitic (16:0) acid was the dominant saturated fatty acid in both fractions of egg lipids regardless of species and population origin. Palmitoleic (16:1 n -7) and docosahexaenoic (22:6 n -3) acids were species specific regardless of population origin. Furthermore, palmitoleic acid levels were significantly higher in lake sturgeon neutral lipids than in that of white sturgeon. Stearic (18:0) and oleic (18:1 n -9) acids were origin specific, with stearic acid at significantly lower levels in wild fish egg neutral lipids. Phospholipid levels were more consistent amongst species and populations. Thus, the environment and species specific life history had an influence on egg fatty acid content. A fatty acid profile was a good tool for differentiating between sturgeon populations.

D'Amours, J., Thibodeau, T.S., and Fortin, R. 2001. Comparison of lake sturgeon (*Acipenser fulvescens*), *Stizostedion* spp., *Catostomus* spp., *Moxostoma* spp., quillback (*Carpoides cyprinus*), and mooneye (*Hiodon tergisus*) larval drift in Des Prairies River, Québec. *Can. J. Zool.* **79**: 1472-1489.

The seasonal, diel, longitudinal, transverse, and vertical variation in rates of larval drift in Des Prairies River (DPR), near Montréal were examined in the species mentioned in the title. Sampling was conducted using drift nets at several transects, stations, depths, and periods of day along a 19 km long section of the river starting about 2 km downstream from the DPR power house. Peak larval drift occurred one week earlier in 1995 than in 1994 for all species except lake sturgeon. The sequence of drifting was similar amongst the study years; with

Stizostedion spp. observed first, then *Catostomus* spp., lake sturgeon, quillback, and mooneye drifting simultaneously, and lastly *Moxostoma* spp. Larval drift profiles showed one major seasonal mode observed simultaneously at all transects with the exception of quillback, which showed a multimodal drift pattern. Drift rates peaked between 21:00 and 03:00 and were minimal during daylight hours with the exception of quillback. Drift rates of lake sturgeon and *Stizostedion* spp. dropped significantly nearer to the DPR power house. Larval drift rates of other taxa showed longitudinal variation, suggesting that they spawned near the powerhouse.

Dabrowski, K. 1994. Primitive actinopterygian fishes can synthesize ascorbic acid. *Experientia* **50**: 745-748.

Paddlefish (*Polyodon spathula*) and white sturgeon (*Acipenser transmontanus*) were fed two diets, one of which was supplemented with ascorbic acid at 120 ppm. The purpose was to determine if primitive actinopterygians could synthesize ascorbic acid, and thus not require dietary Vitamin C to prevent scurvy. The fish fed the diet lacking ascorbic acid did not show evidence of a decline in tissue ascorbic acid concentrations. This was in contrast to studies conducted on teleosts, in which tissue levels declined when no dietary source was present. Actinopterygian tissue Vitamin C levels only increased when fish were fed high levels of ascorbic acid. The author concluded that primitive actinopterygian fishes can, in fact, synthesize ascorbic acid. The taxonomic implications of this were discussed.

Dabrowski, K., Ciereszki, A., Moreau, R., Pan, J., and Bruch, R.M. 1995. Biochemical characteristics of sperm and eggs from the population of lake sturgeon (*Acipenser fulvescens*), in the Wolf River, Wisconsin. *In* World Aquaculture '95: Book of Abstracts. World Aquaculture Society, Baton Rouge, LA. Pagination unknown.

The biochemical characteristics of gametes collected from the 1994 spawning run of the Lake Winnebago lake sturgeon population were analyzed for ascorbic acid concentration. Free amino acid profiles, seminal plasma arylsulfatase activity, and sperm trypsin-like activity were also assessed. Total ascorbic acid concentrations ranged from 63 to 103 µg/g wet

weight and were not related to fish size or age. Arginine level in eggs was high (1.5 $\mu\text{mole/g}$ wet weight), with trace amounts of other amino acids. Sperm concentration and protein concentration in seminal plasma were also presented. Seminal plasma arylsulfatase and sperm trypsin-like proteinase were highly variable.

Dabrowski, K., Czesny, S., Christensen, J.E., Van Eenennaam, J.P., and Doroshov, S.I. 1997. Fatty acid composition of sturgeon eggs - discrimination of domestic and wild origin. *In* Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

Daly, R. 1967. Fishing the big one. *Wis. Conserv. Bull.* 32: 12-13.

Ice fishing in Lake Winnebago, Wisconsin was discussed. The species mentioned included walleye, sauger, white bass, yellow perch, northern pike and sturgeon. In 1966, 4292 sturgeon spearing licenses were sold. In the previous 12 years, approximately 650 sturgeon were speared per year. The record size was a 168 pound sturgeon speared in 1957. Sturgeon spearing gear and methods were discussed.

Damstra, R., and Galarowicz, T. 2004. Stock assessment, spawning movement, and habitat utilization of lake sturgeon in the Manistee River, Michigan. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The Manistee River contained one of the largest remaining lake sturgeon populations in Michigan. A Schnabel population estimate indicated that 56 lake sturgeon made the spawning run in 2003 with a sex ratio of 5.67 males: 1 female. During spawning, lake sturgeon movement was correlated with changes in water temperature. In Manistee Lake, lake sturgeon showed a preference for the less developed northern portion of the lake which was adjacent to wetlands and had a higher density of benthic macroinvertebrates. Continued assessment was needed to ensure successful management of lake sturgeon.

Daugherty, D.J., and Sutton, T.M. 2004. Assessment of remnant lake sturgeon populations in the St. Joseph and Kalamazoo

rivers. Final Report to the Great Lakes Fishery Trust. Project Number 2001.113. Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN. 37 p.

This document was not available for annotating.

Daugherty, D.J., and Sutton, T.M. 2005. Assessment of potential lake sturgeon habitat availability in northern Lake Michigan tributaries: applications to the restoration process. *In* Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 21 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 31 March 2006].

Deacon, J.E., Kobetich, G., Williams, J.D., Contreras, S., and Other Members of the Endangered Species Committee of the American Fisheries Society. 1979. Fishes of North America endangered, threatened, or of special concern: 1979. *Fisheries* 4: 29-44.

The lake sturgeon was listed as "threatened" in the following US states: Alabama, Arkansas, Georgia, Iowa, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Mississippi, New England, New York, Ohio, Pennsylvania, South Dakota, Tennessee, Vermont, Wisconsin, and West Virginia. Habitat destruction was considered the main threat to the species' survival.

Dean, B. 1894. Recent experiments in sturgeon hatching on the Delaware River. *Bull. US Fish Comm.* 13: 335-339.

The mouth of the Delaware River was identified as an important sturgeon fishery area. An estimated 50 to 100 fish were being caught and slaughtered, including spawners. Milt was observed to remain viable fifteen minutes after the fish had died. Excision and extrusion were used as methods to recover the milt. Eggs were observed to remain capable of fertilization outside of water for five minutes. It was thought that under natural spawning conditions eggs were fertilized at extrusion. The three problems that were identified concerning sturgeon culture included difficulties obtaining ripe eggs and milt simultaneously, aeration of eggs, and growth of fungus. Solutions to these problems were discussed.

Deans, N.L. 1987. Looking at the life of a Great Lakes relict. *Aquaticus: J. Shedd Aquar.* **19**: 13-20.

This article briefly discussed the plight of lake sturgeon in the 19th century. Lake sturgeon populations found in Lake Winnebago, Lake Michigan, and their associated tributaries were also discussed. Fred Binkowski's research on lake sturgeon was highlighted.

Dechtiar, A.O. 1972a. New parasite records for Lake Erie fish. *Gr. Lakes Fish. Comm. Tech. Rep.* **17**: iii + 20 p. Available from www.glfc.org/pubs/TechReports/Tr17.pdf [accessed 30 March 2006].

Ten specimens of *Acipenser fulvescens* were taken from the Port Dover area and examined. All fish were host to parasites. *Rhabdochona cascadiella* was found in seven fish and *Diclybothrium armatum* in three.

Dechtiar, A.O. 1972b. Parasites of fish from the Lake of the Woods, Ontario. *J. Fish. Res. Board Can.* **29**: 275-283.

One specimen of lake sturgeon from Lake of the Woods, Ontario, was examined for parasites. The following species were recovered: *Diplostomulum* sp. from the eye, *Diclybothrium armatum* from the gills, and *Crepidostomum lintoni* from the intestine.

DeHaan, P.W. 2003. Demographic and life history characteristics of remnant lake sturgeon populations in the upper Great Lakes basin: inferences based on genetic analyses. M. Sc. Thesis. Michigan State University, Ann Arbor, MI. vii + 93 p.

Genetic diversity, population structure, reproductive ecology and the impacts of stocking lake sturgeon were examined. Genetic analysis was used to determine genetic diversity and population structure in remnant populations in the upper Great Lakes Basin. This data could be used as a baseline for future stocking efforts. A high degree of population structure and significant genetic differences among populations were found. The author concluded that Great Lakes lake sturgeon should not be managed as a single population. Genetic analysis was used to determine parentage in the Black River in Michigan. Polygyny and polyandry were common, reproductive success was highly

variable, and sex ratios were skewed. Genetic analysis was also used to determine the impacts of artificial propagation. A wild population was compared to an introduced population. The author found that the hatchery reared sturgeon did not have the genetic diversity of the wild population and the number of closely related individuals increased.

Delisle, C.E. 1978. Le mercure dans les écosystèmes aquatiques de la Province de Québec, Canada. *Verh. Internat. Verein. Limnol.* **20**: 1947-1955.

This was a report on the mercury levels in aquatic ecosystems in Québec. Of the drainage basins examined, 81 had surface areas over 1,000 square miles (2,589 km²). A map indicating all the drainage systems in Québec was included. The average mercury level in lake sturgeon was 0.24 ppm with a maximum of 2.38 ppm. This level seems to be in the intermediate range, with the predacious pike having an average value of 0.92 ppm.

Dershavin, A. 1910. Zwei beachtenswerten Funde, Hypania und Polypodium in Wolga-Delta. *Zool. Anz.* **36-24**: 408.

Free living polyps were collected and sexually mature polyps were found in the Volga delta. Cited in Smol'yanov and Raikova (1961).

DesJardine, R.L., Gorenflo, T.K., Payne, R.N., and Schrouder, J.D. 1995. Fish-community objectives for Lake Huron. *Gr. Lakes Fish. Comm. Spec. Publ.* **95-1**: 37 p. Available from www.glfc.org/pubs/SpecialPubs/Sp95_1.pdf [accessed 30 March 2006].

Lake sturgeon were identified as part of the warmer water fish community in inshore waters. The key objective was to increase the species' abundance to the point that its threatened status in the United States could be removed. In addition, the maintenance and rehabilitation of sturgeon populations in Canada was also desired. Restoration plans were briefly mentioned.

DesLandes, J., Guénette, S., and Fortin, R. 1994. Evolution of fish communities in environments affected by the development of the La Grande Complex, phase I (1977-1992). *Hydro-Québec and the Université du Québec à Montréal.* 85 p. + map.

This report discussed the impacts of the La Grande complex on fish communities. Several species were discussed including northern pike, lake whitefish, longnose and white suckers, cisco, lake trout, burbot, walleye, and lake sturgeon. The only area with sufficient catches of lake sturgeon to allow discussion of abundance and reproductive success was the Eastmain River. Sturgeon yields increased after the 1980 cutoff to create the Opinaca reservoir. However, yields became progressively lower towards the end of the series. Lake sturgeon may have had recruitment problems after the cutoff because of changes in accessibility to spawning grounds and/or changes in the environment.

Desrochers, D. 1996. Reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à Cascades-Nord. Milieu inc., pour le module Environnement, service Services techniques, région Maisonneuve, Hydro-Québec. Montréal, Québec. viii + 54 p. + apps.

A study was conducted between May 13 and June 25, 1996, to confirm the use of the Cascades-Nord area by lake sturgeon in the spring. This area is situated downstream of the Pointe-des-Cascades dam. Drift nets were set to collect eggs and gill nets (mesh size: 20.3 and 25.4 mm) were set to collect juvenile and adult fish. Seven fish were tagged with radio transmitters. No sturgeon eggs were collected after 439.4 hours of effort over 22 nights and it was thought that no significant spawning events took place in the Faucilles rapids in 1996. Out of a total of 189 lake sturgeon captured, 95% were taken at 7 of the 20 sampling stations. Catch per unit effort peaked between June 3 and 9, was zero for 10 days after, and increased between June 20 and 24. No lake sturgeon were captured at the Faucilles rapids, although one tagged fish spent two days in the rapids indicating that the use of the rapids by lake sturgeon is sporadic. The study found three important sites where lake sturgeon were most abundant: near navigation buoy AM-10 (41.8% of captures), near the entrance to the Soulanges Canal (32.3% of captures), and the Cascades island (15.3% of captures). The average size of fish captured in gill nets was 1,094 mm. Results from the study indicated that the lake sturgeon observed during the spring in the area were mature fish returning from spawning grounds (accompanied by immature fish), rather than mature fish searching for spawning sites.

Desson, E. 1993. Larval lake sturgeon (*Acipenser fulvescens*) assessment and collection, Sturgeon River 1992. Ontario Ministry of Natural Resources, Lake Nipissing Fisheries Assessment Unit. 14 p.

Drift nets were employed to capture lake sturgeon in the Sturgeon River in June of 1992. The larval sturgeon were collected for rearing in an indoor facility, to obtain catch and effort data that could be compared with similar projects, and to determine sampling criteria and methods. A map of the section of the Sturgeon River sampled, showing net placement locations and various habitat characteristics, is provided. A total of 473 sturgeon larvae were captured over 318.1 net hours, resulting in a catch per unit effort of 4.14 fish per hour, per square metre of net opening. Results were compared to a similar study conducted on the Wolf River. A list of 8 recommended sampling procedures was included.

Dettlaff, T.A., Ginsburg, A.S., and Schmalhausen, O.I. 1993. Sturgeon fishes developmental biology and aquaculture. Springer-Verlag, Heidelberg, Germany. 300 p.

Several topics pertaining to sturgeon species including lake sturgeon were discussed in detail. Some of these topics included oocyte maturation and ovulation, embryonic development, development of prelarvae, environmental conditions of spawning, and development and control of incubation conditions.

Dettmers, J.M., Gutreuter, S., Wahl, D.H., and Soluk, D.A. 2001. Patterns of abundance of fishes in main channels of the upper Mississippi River system. Can. J. Fish. Aquat. Sci. 58: 933-942.

The objectives of this study were to examine the feasibility and effectiveness of bottom trawling in the navigation channels of rivers, to estimate and model seasonal catch patterns for important riverine species, and to determine estimates of numeric and biomass densities to gain an understanding of the importance of the main channel to fishes of the upper Mississippi River system. Bottom trawling was conducted in the navigation channels of Pool 26 of the Mississippi River and the lower Illinois River. Lake sturgeon were primarily encountered in summer, fall and winter in the Mississippi River. Their numeric density was estimated at 0.17/ha, and their

biomass density at 0.41 kg/ha. Lake sturgeon were absent from the lower Illinois River.

Diana, J.S., and Webb, P.W. 2003. Growth appetite of juvenile lake sturgeon *Acipenser fulvescens*. Michigan Department of Natural Resources. Fisheries Research Report 2063: 18 p.

Lake sturgeon with an initial weight of 8 to 9 g, kept at a temperature of 17.5°C, fed brown worms twice a day for 56 days, increased from -1.5% body wet weight/day (BW/d) at zero ration to 2.6% BW/d at a ration of 13.2% BW/d. Fish fed larger rations had higher energy densities and lower water content. Appetite (the average volitional daily food consumption) was examined and compared for lake sturgeon weighing 6.3 g fed once and twice a day. Appetite was $12.8 \pm 1.6\%$ BW/d for fish fed twice a day and $7.4 \pm 0.8\%$ BW/d for fish fed once a day. Growth rates and food consumption in one feeding per day averaged $1.8 \pm 0.2\%$ BW/d and $9.4 \pm 2.2\%$ BW/d respectively. They were also independent of weight for lake sturgeon weighing 10 to 1,322 g. Lake sturgeon daily food consumption varied as much as 15 times for fish fed twice a day. In addition, daily food consumption was correlated with previous consumption history, but mechanisms causing the effect could not be identified. Gorging ability may be important to species that feed on patchy prey. The authors concluded that management of lake sturgeon would be aided by selecting large fish for stocking.

Dick, T.A. [2004]. Lake sturgeon studies in the Pigeon and Winnipeg rivers and biota indicators. Department of Zoology, University of Manitoba, Winnipeg, MB. xiv + 429 p. [Unpublished].

This comprehensive report documented a study on lake sturgeon populations in the Pigeon River at Round Lake and in the Winnipeg River. Topics covered included: current knowledge; population estimates; movements and habitat use; enhancements; feeding tags; bathymetry; current; and substrate at Seven Sisters on the Winnipeg River; and aquatic biota in the east side of Lake Winnipeg. Key appendices included: a draft COSEWIC status report on lake sturgeon in Canada (an interim draft that has since been extensively revised); an annotated lake sturgeon bibliography; and a field guide for the identification of stages of general development in lake sturgeon.

Dick, T.A., and Choudhury, A. 1992. The lake sturgeon, *Acipenser fulvescens* (Chondrostei: Acipenseridae): an annotated bibliography. Can. Tech. Rep. Fish. Aquat. Sci. 1861: iv + 69 p.

This document contained 296 references and covered the years 1817 to 1991. All of the references are included in this bibliography.

Dick, T.A., and MacBeth, B. 2003. First Nations participation in determining the status of a species at risk, p. 291-300. In J. Oakes, R. Riewe, K. Wilde, A. Edmunds and A. Dubois (ed.) Native Voices in Research. Department of Zoology, Faculty of Environment and Faculty of Graduate Studies, University of Manitoba, Winnipeg, Manitoba.

This article discussed the significance of sturgeon to First Nations communities. It is necessary to include First Nations communities in conservation efforts because many of the remaining populations are located within them. In addition, these communities possess the only historical information on lake sturgeon populations. The authors concluded that successful long-term conservation efforts and recovery strategies must involve traditional/historical knowledge and other information from First Nations communities.

Dick, T.A., Holloway, H.L., and Choudhury, A. 1991. *Polypodium* sp. (Coelenterata) from lake sturgeon (*Acipenser fulvescens*, Rafinesque) in the prairie region of Canada. J. Parasitol. 77: 483-484.

Polypodium sp. was reported in eggs of lake sturgeon from the Nelson River (Hudson Bay drainage) in Manitoba for the first time. Infections were only found in sturgeon with eggs of 3 mm in diameter or more and ranged from 1-179 infected eggs per set of gonads. All specimens of *Polypodium* recovered were in the stolon stage with a chain of buds, with or without tentacles.

Dick, T.A., Letander, H., Morrisseau, K., and Paci, C. 1998. Namy: a northern resource in crisis, p. 181-190. In J. Oakes and R. Riewe (ed.) Issues in the North Volume III. Canadian Circumpolar Institute Occasional Publication Number 44.

The authors outlined the biology of sturgeon and their variety of uses to indigenous people. The

authors discussed the importance of incorporating traditional ecological knowledge (TEK) in scientific research studies. Indigenous people provided valuable information because of their intimate knowledge of the history of, and changes to, river systems and landscapes. In order to make sound management decisions for the long-term, various levels of government should work to improve communications between scientific and indigenous communities.

Dick, T.A., Lu, M., and Barrows, F.T. 1996. Lake sturgeon: a freshwater species with a future. *Bull. Aquacult. Assoc. Can.* **96**: 50-52.

Rising interest in lake sturgeon was a result of mitigation and compensation to aboriginal people. Costs for culturing larval lake sturgeon to stocking size were high. Best results to date for fish fed formulated diets were 60% survival and growth rates up to 6% per day. Lake sturgeon may not be as slow growing as once thought as 3-year old sturgeon grown at 15°C have reached 5 kg.

Dickson, T. 1991. Minnesota's gentle giant. *Minn. Volun.* **May-June, 1991**: 27-31.

This article described what the author considered should be Minnesota's state fish, the lake sturgeon. The high regard for sturgeon flesh and roe by the royalty and aristocracy of Europe was described with anecdotes of past decrees reserving the sturgeon for royalty. The important role of sturgeon in aboriginal cultures was also noted. The familiar tale of wanton destruction of sturgeon during the early days of commercial fishing was recounted. The effects of dams, erosion and pollution on sturgeon populations were discussed. The article also described more recent research by the Department of Natural Resources, such as tagging fish and restocking with hatchery raised fingerlings (36,000 fingerlings were stocked over the previous 7 years). Registering angled fish in Wisconsin was considered a worthwhile conservation measure.

Dieckman, M. 1963. Sturgeon on the rocks. *Wis. Cons. Bull.* **28**: 14-15.

The author, a conservation warden, described fishing for sturgeon in shallow to moderately deep rock pools. The warden mentioned several cases of illegal fishing he had witnessed and how the culprits were encountered and arrested.

The sturgeon were reported to be quite plentiful. Their average weight ranged from 25-45 pounds with the occasional 60-70 pound, and a rare 100 pound fish being taken. The importance of legislation and enforcement were emphasized as deterrents to illegal fishing, and for the protection of this potentially vulnerable species.

DiLauro, M.N., Kaboord, W.S., Walsh, R.A., Krise, W.F., and Hendrix, M.A. 1998. Sperm-cell ultrastructure of North American sturgeons. I. The Atlantic sturgeon (*Acipenser oxyrinchus*). *Can. J. Zool.* **76**: 1822-1836.

Sperm-cells of Atlantic sturgeon (*Acipenser oxyrinchus*) and lake sturgeon (*Acipenser fulvescens*) were examined using scanning electron microscopy. Significant differences were found in four of nine metrics, all in the head region of the cell. Atlantic sturgeon sperm cells were shorter than lake sturgeon sperm cells. Comparisons were also made amongst known sperm cell structures of other sturgeon species. Furthermore, the fine structure of Atlantic sperm cells was examined using transmission electron microscopy. Sperm cells of Atlantic, stellate, and white sturgeons had radial symmetry along the longitudinal axis, an elongate shape, a distinct acrosome, and endonuclear canals. However Atlantic sperm cells had a smaller total length and width than stellate and white sturgeon, and two endonuclear canals as compared with three in stellate and white sturgeon. Atlantic sturgeon sperm cells also had a structural connection between the nuclear fossa and proximal centriole. Sperm-cell nuclei of white and stellate sturgeon were elongate trapezoids with a narrower anterior end, whereas Atlantic sturgeon had a wider anterior end. Structural similarities between species possibly indicated a common evolutionary relationship. The authors concluded that there was a closer relationship between the white and stellate sturgeon than between either of these species and the Atlantic sturgeon.

DiLauro, M.N., Krise, W.F., and Fynn-Aikins, K. 1998. Growth and survival of lake sturgeon larvae fed formulated diets. *Prog. Fish-Cult.* **60**: 293-296.

Formulated diets were given to larval lake sturgeon 2 weeks after first-feeding in order to determine a suitable formulated diet and discover diet-related differences in survival and

growth of larval lake sturgeon. There were a total of five formulated diets fed to the fish with brine shrimp used as the control. Results showed that lake sturgeon fed only brine shrimp were greater in mean length at 68 days old than sturgeon fed the other formulated diets. In addition, the mean weight of fish fed brine shrimp was greater than that of fish fed the Tunisian, Biodiet, and BioKyowa diets. The larvae likely became imprinted on brine shrimp during the 2 weeks immediately following exogenous feeding because there was no indication that the larvae fed on the formulated diets.

DiLauro, M.N., Kaboord, W.S., and Walsh, R.A. 1999. Sperm-cell ultrastructure of North American sturgeons. II. The shortnose sturgeon (*Acipenser brevirostrum*, LeSueur, 1818). *Can. J. Zool.* **77**: 321-330.

This study described the sperm cell ultrastructure and morphology of the shortnose sturgeon. The sperm was collected from shortnose sturgeon from the Hudson River, New York and examined using transmission electron microscopy and scanning electron microscopy. The sperm cell of the shortnose sturgeon was similar to the sperm cells of other sturgeon species with the exception of Atlantic sturgeon. It is closest in shape to that of the lake sturgeon, and closest in length to those of Russian and stellate sturgeons. The significance of this research with respect to aquaculture was discussed.

DiLauro, M.N., Kaboord, W.S., and Walsh, R.A. 2000. Sperm-cell ultrastructure of North American sturgeons. III. The lake sturgeon (*Acipenser fulvescens* Rafinesque, 1817). *Can. J. Zool.* **78**: 438-447.

This study presented the first ultrastructural description of the lake sturgeon sperm cell. By using transmission electron microscopy it was determined that this species had radial symmetry, an elongate shape, a distinct acrosome, a defined head region, a single flagellum, and endonuclear canals. The mean length of the sperm cell body was roughly 7.13 μm and the length of the flagellum was approximately 50 μm , with a total cell length of about 57 μm . The lake sturgeon sperm cell was significantly longer and somewhat wider than the Atlantic sturgeon sperm cell. Lake, shortnose, white, and stellate sturgeons all possessed elongate trapezoid sperm cell nuclei, with the

anterior end being the narrowest, and three endonuclear canals. The acrosome of the lake sturgeon sperm cells had longer posterolateral projections than that of Atlantic or shortnose sturgeon. Similar to Atlantic and shortnose sturgeon, the lake sturgeon sperm cell had a structural connection between the nuclear fossa and the proximal centriole. The sperm cell of lake sturgeon most closely resembled that of shortnose sturgeon in ultrastructure, size, and shape. It appeared that there was a closer evolutionary link between lake and shortnose sturgeon than with Atlantic sturgeon.

DiLauro, M.N., Walsh, R.A., Peiffer, M., and Bennett, R.M. 2001. Sperm-cell ultrastructure of North American sturgeons. IV. The pallid sturgeon (*Scaphirhynchus albus* Forbes and Richardson, 1905). *Can. J. Zool.* **79**: 802-808.

Sperm-cell morphology and ultrastructure of pallid sturgeon were examined using transmission and scanning electron microscopy. Obtained metrics were compared with those of other sturgeon species. Similarities were found amongst pallid sturgeon and white, lake, stellate, Chinese, Russian, and shortnose sturgeons. They all shared a tapered nuclear diameter from the posterior to anterior. The sperm cell of pallid sturgeon was similar in size to the Atlantic sturgeon. The posterolateral projections (PLP) were longer, had the shape of a hollow cone, and were organized in a spiral about the longitudinal axis of the cell. The structural arrangement of the distal centriole of the midpiece was the same as the proximal centriole, having nine sets of microtubular triplets around the outside of the centriole.

Dion, R. 1990. Experimental commercial sturgeon fishery and lake whitefish biological data acquisition on the Rupert River, Mistissini, Québec. Cree Regional Authority Manuscript Report. 7 p.

The objective of this study was to determine costs associated with the start of a small scale sturgeon fishery in the Waswanipi area. The commercial sturgeon fishery took place in September at three locations (a map is referred to, but was not included in the report) with quotas of 683 kg, 600 kg and 345 kg, respectively. In total, 19 nets, 8" mesh, 50 m in length by 2 m were used. The fisher was paid \$1.85/lb of dressed fish and transportation costs were funded by the Cree Regional Authority.

Caviar, in good condition was sold to La Poissonnerie du Nord for \$35/lb. An experimental fishery was conducted on the Rupert River. The quota was reached at each of the commercial sturgeon sites in a short time. A total of 304 lake sturgeon were caught in the commercial fishery, of which 79 were released. In the experimental fishery, 13 lake sturgeon were caught. Total costs associated with the commercial fishery were \$6,018.94 and total revenues were \$5,781.00. The author considered the commercial test fishery a success, but future economic viability will depend on fishery efficiency, and price per delivered fish. Methods to minimize transportation costs were discussed.

Dittman, D.E., and Lowie, C. 2001. Indications of improvement in aquatic habitats for lake sturgeon in the Genesee River, p. 28. *In* Abstracts from the 44th Conference on Great Lakes Research, June 10-14, 2001. Great Lakes science: making it relevant. [Abstract only].

To identify high quality habitat for lake sturgeon, water flows, depths, temperatures, and substrate flows were recorded across transects of the Genesee River. Substrates and macroinvertebrates were also sampled. Suitable spawning habitat was found near the Lower Falls, and summer foraging habitat was found throughout the river. The highest diversity of invertebrates was found in upstream sandy/silty sites.

Dittman, D.E., and Zollweg, E.C. 2005. Assessment of habitat use by stocked lake sturgeon in the Genesee River. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. [Poster presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/posterabstracts.htm> [accessed 31 March 2006].

Dittman, D., Lowie, C., and Pearsall, W. 2000. Lake sturgeon restoration research project in the Genesee River, p. 9-10. *In* T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 30 March 2005].

Dogiel, V.A. 1940. New finding places and new hosts of *Polypodium hydriforme*. *Zool. Zh.* **19**: 321-323.

The range of *Polypodium hydriforme* was considerably extended. It was reported from *Acipenser gueldenstaedti* and *A. stellatus* from the River Sulak (west of Caspian Sea) and from *A. gueldenstaedti* from the River Don.

Dogiel, V.A. 1954. Investigations into parasitological problems in connection with reconstruction of fish farm. *Vopr. Ikhtiol.* **2**: 57-68.

Various parasites of commercial importance to fish were discussed, including, *Diplostomum*, *Diphyllbothrium*, *Dactylogyrus*, *Contracaecum*, and others. One paragraph on p. 65 dealt with the problems of *Polypodium* infection.

Dominion Bureau of Statistics [Canada]. 1958. p. 1-42. *In* Fisheries statistics of Canada: Ontario, Prairie Provinces, and Northwest Territories 1956. Fisheries Section of the Industry and Merchandising Division.

Sturgeon harvests of 27,000 lbs and 45,000 lbs were reported from Manitoba in 1955 and 1956, respectively. In Ontario, 162,000 lbs were caught in 1955 and 140,000 lbs in 1956. In Saskatchewan, 11,000 lbs were caught in 1955 and 10,000 lbs in 1956.

Dominion Bureau of Statistics [Canada]. 1959. p. 1-44. *In* Fisheries statistics of Canada: Ontario, Prairie Provinces, and Northwest Territories 1957. Fisheries Section of the Industry and Merchandising Division.

A total catch of 85,000 lbs of sturgeon was reported for Manitoba in 1956-1957. This amount was almost double that of the previous year. Six thousand lbs of caviar were harvested in the 1956-1957 fishing season. In Ontario, 140,000 lbs were caught in 1956 and 176,000 lbs in 1957. In Saskatchewan, the catch decreased from 10,000 lbs in 1956 to 7,000 lbs in 1957.

Dominion Bureau of Statistics [Canada]. 1961a. Fisheries statistics of Canada: Manitoba 1960. Industry and Merchandising Division. Catalogue No. **24-210**: 11 p.

A summary of commercial fishery statistics for Manitoba in 1959 and 1960 was given. The sturgeon catch fell from 34,000 lbs in 1959 to 22,000 lbs in 1960.

Dominion Bureau of Statistics [Canada]. 1961b. Fisheries statistics of Canada: Ontario 1960. Industry and Merchandising Division. Catalogue No. **24-209**: 11 p.

A summary of commercial fishery statistics for Ontario in 1959 and 1960 was given. The sturgeon catch increased from 180,000 lbs in 1959 to 185,000 lbs in 1960.

Dominion Bureau of Statistics [Canada]. 1962a. Fisheries statistics of Canada: Saskatchewan 1960. Industry and Merchandising Division. Catalogue No. **24-211**: 9 p.

A summary of commercial fishery statistics for Saskatchewan in 1959 and 1960 was given. The sturgeon catch fell from 6,000 lbs in 1959 to 2,000 lbs in 1960.

Dominion Bureau of Statistics [Canada]. 1962b. Fisheries statistics Ontario 1961. Industry and Merchandising Division. Catalogue No. **24-209**: 12 p.

A summary of commercial fishery statistics for Ontario in 1960 and 1961 was given. The sturgeon catch increased from 185,000 lbs in 1960 to 196,000 lbs in 1961.

Dominion Bureau of Statistics [Canada]. 1963a. Fisheries statistics Manitoba 1961. Industry and Merchandising Division. Catalogue No. **24-210**: 11 p.

A summary of commercial fishery statistics for Manitoba in 1960 and 1961 was given. The sturgeon catch decreased from 22,000 lbs in 1960 to 8,000 lbs in 1961.

Dominion Bureau of Statistics [Canada]. 1963b. Fisheries statistics Saskatchewan 1961. Industry and Merchandising Division. Catalogue No. **24-211**: 9 p.

A summary of commercial fishery statistics for Saskatchewan in 1960 and 1961 was given. The sturgeon catch was 2,000 lbs in 1960 and 3,000 lbs in 1961.

Dominion Bureau of Statistics [Canada]. 1969a. Fisheries statistics Manitoba 1968. Manufacturing and Primary Industries Division. Catalogue No. **24-210**: 11 p.

A summary of fisheries statistics for Manitoba in 1967 and 1968 was given. No sturgeon were caught in 1967. In 1968 the catch was 2,000 lbs.

Dominion Bureau of Statistics [Canada]. 1969b. Fisheries statistics Ontario 1968. Manufacturing and Primary Industries Division. Catalogue No. **24-209**: 12 p.

A summary of fisheries statistics for Ontario in 1967 and 1968 was given. The sturgeon catch decreased from 102,000 lbs in 1967 to 80,000 lbs in 1968.

Dominion Bureau of Statistics [Canada]. 1970. Fisheries statistics Saskatchewan 1968. Manufacturing and Primary Industries Division. Catalogue No. **24-211**: 6 p.

A summary of fisheries statistics for Saskatchewan in 1967 and 1968 was given. The value of sturgeon products increased from \$8,000 in 1967 to \$15,000 in 1968. Lake sturgeon harvest weight was not provided.

Dominion of Canada, Department of Fisheries. 1886. Annual Report of the Department of Fisheries, Dominion of Canada, for the Year 1885.

This report summarized fish harvests geographically by species for Canada. Provinces and Territories that reported a commercial harvest of sturgeon in 1885 included Manitoba, Ontario, Québec, and the Northwest Territories.

Dominion of Canada, Department of Fisheries. 1888. Annual Report of the Department of Fisheries, Dominion of Canada, for the Year 1887.

This report summarized fish harvests geographically by species for Canada. Provinces and Territories that reported a commercial harvest of sturgeon 1887 included Manitoba, Ontario, Québec, and the Northwest Territories.

Dominion of Canada, Department of Fisheries. 1891. Annual report of the Department of Fisheries Dominion of Canada for the year 1890. Sessional Paper No. 8a. Pagination unknown.

In 1890, A. McQueen reported that 111,613 lbs of sturgeon were caught in Manitoba and the Northwest Territories. In 1889 and 1890, 45,830 lbs and 231,986 lbs of sturgeon were exported to the United States, respectively.

Dominion of Canada, Department of Fisheries. 1938. Eighth annual report of the Department of Fisheries (seventy-first annual fisheries report of the Dominion) for the year 1937-38.

This report summarized fish harvests geographically by species for Canada. Provinces that reported a commercial harvest of sturgeon in 1937 and 1938 included Manitoba, Ontario, Saskatchewan, and Québec.

Dores, R.M., Hoffman, N.E., Chilcutt-Ruth, T., Lancha, A., Brown, C., Marra, L., and Youson, J. 1996. A comparative analysis of somatolactin-related immunoreactivity in the pituitaries of four neopterygian fishes and one chondrosteian fish: an immunohistochemical study. *Gen. Comp. Endocrinol.* **102**: 79-87.

Lake sturgeon were tested for somatolactin-immunopositive (SL-IR) cells using an antiserum to cod SL. SL-positive cells were not detected in the pars intermedia.

Doroshov, S.I. 1985. Biology and culture of sturgeon acipenseriformes, p. 251-274. *In* J. F. Muir and R. J. Roberts. (ed.) Recent advances in aquaculture, volume 2. Croom Helm, London.

This review highlighted methods, important problems, and issues in world sturgeon aquaculture. Gaps in knowledge of the species' genetics, nutritional requirements, and pathology were identified, and no F₂ generation of any sturgeon species had yet been established in hatcheries. Aquaculture programs and methods in the Soviet Union were reviewed in considerable detail. In the U.S., jar incubators were successfully used for the eggs of lake sturgeon (among other sturgeon and paddlefish).

Doroshov, S.I., and Binkowski, F.P. 1985. Epilogue: a perspective on sturgeon culture, p. 147-151. *In* Binkowski, F. P. and S. I. Doroshov (ed.) North American Sturgeons: biology and aquaculture potential. Dr. W. Junk Publishers, Dordrecht.

This document provided a summary of sturgeon culture and related research. The history of sturgeon culture was discussed. At writing, the main areas of industrial sturgeon culture, consisting of the ranching of wild stocks, were in the Caspian and Azor Seas. The main species propagated were hausen, stellate, Russian, Schip, and Siberian sturgeons and starlet. It was noted that the University of Wisconsin has raised F1 lake sturgeon to market size in cages. Culture techniques and associated research were also discussed.

Doroshov, S.I., Bruch, R.M., and Binkowski, F.P. 2004. The past and present of sturgeon management and rehabilitation. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The authors attributed the first principles developed for sturgeon management to Baer and Danilevski (1860). These included the protection of the natural river flow and the prevention of overfishing. The history of sturgeon management, current management and rehabilitation practices, and future needs were discussed.

Downs, W. 1975. Fish of Lake Michigan. University of Wisconsin Sea Grant College Program **WIS-SG-74-121**: 30 p.

A brief one page account of the lake sturgeon, with a drawing, was provided. Lake sturgeon were characterized as reaching 3-5 feet in length and 80-100 pounds in weight.

Doyon, C., Boileau, S., Fortin, R., and Spear, P.A. 1998. Rapid HPLC analysis of retinoids and dehydroretinoids stored in fish liver: comparison of two lake sturgeon populations. *J. Fish Biol.* **53**: 973-986.

High-performance liquid chromatography (HPLC) was used to study major retinoids of the liver in lake sturgeon from two lakes in Québec. Of the four HPLC peaks (approximately 90% of all liver retinoids) dehydroretinyl palmitate/oleate

accounted for the largest proportion (50-60%). Most retinoids showed significant positive correlations with age, but only in Lake Berthelot. All major retinoid concentrations were up to 40 fold lower in the Lake Saint-Louis population, and possible reasons for this were discussed.

Doyon, C., Fortin, R., and Spear, P.A. 1999. Retinoic acid hydroxylation and teratogenesis in lake sturgeon (*Acipenser fulvescens*) from the St. Lawrence and Abitibi region, Québec. Can. J. Fish. Aquat. Sci. **56**: 1428-1436.

Lake sturgeon from the St. Lawrence River were estimated to have a 2.9% occurrence of fin and craniofacial malformations caused by insufficient or excessive levels of all-trans-retinoic acid (RA). Of larvae reared in artificial streams from the St. Lawrence River and the Abiti region, the St. Lawrence larvae showed a higher occurrence of fin malformations (6.3%). The authors wished to determine if differences in malformation rates were related to metabolic imbalances of RA. Cytochrome P-450 dependent conversion to 4-hydroxyretinoic acid (4-OH-RA) was investigated. Enzyme activity decreased with increasing age and gonad development in sturgeon from Abiti, but no significant effects of sex, age, length, or gonad development were found. In sturgeon from the St. Lawrence River, the rate of 4-OH-RA formation was 3.5 times greater and concentrations of cytochrome P-450 were 20 times greater in the liver. Liver retinoid concentrations were negatively correlated with RA hydroxylation rates. These results supported the hypothesis that cytochrome P-450 dependent RA metabolism increased by chemical contaminants was related to malformations in St. Lawrence sturgeon.

Drozdowski, A. 1972. *Polypodium hydriforme* (Coelenterata): a parasite of the Acipenseridae fishes. Przegl. Zool. **16**: 20-25.

The history and morphological features of the stages of the life-cycle of *Polypodium* were reviewed and described with diagrams. The present state of knowledge on this parasite was reviewed, and the species was found to exhibit many unique characteristics.

Dubreuil, R., and Cuerrier, J.P. 1950. Cycle de maturation des glandes génitales chez l'esturgeon de lac (*A. fulvescens* Raf.). Rapport sur l'analyse du matériel recueilli au cours du

printemps de 1949 au barrage Fitzroy-Cuyon, lac Des Chênes, rivière Ottawa. Ministère de l'Industrie et du Commerce du Québec, et au Conseil National de Recherches, Ottawa, ON. 50 p. + apps.

A study was conducted on the spawning cycle of lake sturgeon from the Ottawa River, downstream from the Des Chats dam down to Des Chênes Lake in 1947 and 1949. Prior studies had indicated that males spawned every two years while females spawned every four or five years. In 1949, 404 fish were captured during the spawning season using gill nets (203 mm and 305 mm stretched mesh) of which 349 were tagged and released and 55 were terminated and sampled for biological data. Biological characteristics examined included length and age frequency distributions, length at age, length-weight, condition factor, length at maturity and fecundity. Of the fish that were released, 192 were mature males, 32 were mature females, 20 were immature females and 105 were undetermined. Three fish tagged in 1947 were recaptured in 1949. Length-at-age and length-weight data showed that males reached maturity at a length of 762-787 mm and 19-20 years of age, while females matured at lengths between 838-864 mm and 26 years of age. It was calculated that one kilogram of ovary contained 54,000 eggs with a diameter of 3 mm. Lake sturgeon fed on lamellibranchs, gastropods, crustaceans and insects.

Dubuc, N., Thibodeau, S., DesLandes, J., and Fortin, R. 1996. Utilisation du milieu en période de fraie abundance des géniteurs et succès de reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à la frayère de la rivière des Prairies au printemps de 1996. Rapport préparé pour le Module Environment, Services Techniques, Région Maisonneuve et pour la Vice-présidence Environnement, Hydro-Québec. Université du Québec à Montréal, Département des sciences biologiques. ix + 91 p.

Hydro-Québec proposed to excavate a canal on the right bank (facing downstream) of the Rivière des Prairies in order to prevent the public from gaining access to a shallow area of the river located in front of the dam spillway. To compensate for the potential loss of spawning habitat, Hydro-Québec proposed to restore a section of spawning grounds at the base of the spillway. To assess whether sturgeon could be directed towards the spawning grounds, two

alternative flow rates were examined in 1996 (gates 3-5 and 13 were opened followed by gates 3-13). The capture of lake sturgeon using experimental index gill nets along with the presence of eggs on the river bottom suggested that spawning took place between May 17 and June 10. During that time period, the water temperature increased from 10.5°C to 18.4°C and the river flow rate decreased from 1,892 to 1,215 m³/s. The alternating flow rates did not influence the capture of sturgeon in experimental gill nets or the harvesting of eggs at various sampling stations. Experimental gill netting done between June 5 and 12, near the end of the spawning season, suggested that adult lake sturgeon were located at the northern extremity of the spillway. Large numbers of deposited eggs were situated downstream from the central portion of the base of the spillway where the substrate was characterized as smooth rock. This area was identified for further habitat restoration. From the 1,309 lake sturgeon tagged in 1996, 124 were re-captured between May 15 and June 12. It was estimated that 7,166 (Schnabel method) or 9,657 (Seber-Jolly method) lake sturgeon used the Rivière des Prairies spawning grounds. Based on length classes, sex, and maturity stage, an estimated 199 million (Schnabel method) or 268 million (Seber-Jolly method) eggs may have been deposited. Larvae hatched between June 6 and 21, based on transects, and moved 800 m downstream from the Pie-IX bridge. Ninety-five percent of larvae hatched at night, most between 21h00 and 00h00. Approximately 1,235,000 larvae hatched from the spawning grounds, giving a larvae:egg survival ratio of 0.46-0.62%. The survival rate was of the same magnitude observed in 1995 (0.67%) when the hatching took place on spawning areas presumed of lesser quality than in 1996.

Dubuc, N., Thibodeau, S., and Fortin, R. 1997. Impact de l'aménagement d'un nouveau secteur de frayère sur l'utilisation du milieu en période de fraie et le succès de reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à la frayère de la rivière des Prairies au printemps de 1997. Rapport préparé pour la Direction Production, Beauharnois-Gatineau, Hydro-Québec. Université du Québec à Montréal, Département des sciences biologiques. xiv + 81 p. + apps.

In autumn of 1996, Hydro-Québec excavated a canal on the right bank of the des-Prairies River

to prevent public access shoals below the des-Prairies River generating station. A spawning ground for lake sturgeon was created at the base of the spillway in order to compensate for possible habitat loss from the excavation. The objective of the study was to evaluate the use and spawning success of lake sturgeon during reproduction. Fish were sampled in 1997 using experimental gill nets and eggs collected from trays containing artificial substrate. Back calculation of fertilized eggs indicated that the spawning took place between May 22 and June 10 while the water temperature was increasing from 10.7 to 19.7°C and the flow was decreasing from 1,846 to 1,215 m³/s. Spawning peaked between May 25 and 30 at water temperatures between 12.2 and 14.2°C and flow rates between 1,705 and 1,569 m³/s. The largest capture of spawners occurred in association with the new spawning ground. The number of lake sturgeon that used spawning grounds in the des-Prairies River in 1997 was estimated at 4,732 using the Schnabel method and 4,452 using the Seber-Jolly method. These results were approximately 1.5-2 times lower than estimates from 1995-6, while catch-per-unit-effort and egg counts from trays were 4 times lower than previous years. The use of spawning areas other than those sampled may have caused discrepancies in the results. Larvae hatched between June 4 and 25 peaking between the 12th and 14th with 95% hatching at night generally between 21h00 and 00h00. Larval abundance was estimated at 6.3 million in 1997 which was higher than the previous two years.

Duckworth, G., Mosindy, T., Armstrong, E., Goodchild, G., Preston, G., Hart, M., and Jessop, C. 1992. A draft management strategy for lake sturgeon in Ontario, Ed. 6. Ontario Ministry of Natural Resources. Pagination unknown. [Unpublished].

This document was not available for annotating.

Dudich, N.J. 1967. Systematisches Verzeichnis der Tierwelt der Donau mit einer zusammenfassenden Erläuterung. Limnol. Donau 3: 41-69.

This article was not available for annotating.

Dumas, R., Trepanier, F., and Simoneau, M. Date unknown. Fish problems and community-based solutions: the lake sturgeon case in the L'Assomption River watershed. Société de la Faune et des Parcs du Québec, Québec, QC. 1 p. [Abstract only].

Two lake sturgeon spawning sites in the L'Assomption river watershed were exposed to raw municipal sewage, land slides, and dam-operated water level fluctuations. A five-year study was conducted to compare sturgeon larval production before and after the construction of a sewage treatment plant on the L'Assomption River. Larval production was also monitored at another spawning site in the watershed: the Ouareau River. Before sewage treatment in the L'Assomption River there was massive egg and larval mortality. After sewage treatment, larval production increased by a factor of 10. Ouareau River results were not included in the abstract, but it was noted that the negative impacts of habitat loss caused by land slides were highlighted. Conservation measures were briefly discussed.

Dumeril, A. 1870. Histoire naturelle des poissons ou ichthyologie generale, Tom. II. Ganoides, Dipnes, Lophobranches. Paris. Pagination unknown.

In this second volume of the natural history of world fishes, the author covered the sturgeon under the Ganoids. The following species were mentioned from various freshwater locations in North America: *Acipenser maculosus* (p. 113); *A. serotinus* (p. 158, Ohio R.); *A. ohioensis* (p. 156, Wabash R.); *A. rhynchaeus* (p. 111, Lake Superior); *A. copei* (p. 108, maybe Upper Missouri); *A. rauchii* (p. 118, Osage R.); *A. richardsonii* (p. 120, Missouri R.); *A. anasimos* (p. 122, Missouri R.); *A. paranasomos* (p. 124, Huntsville Alabama); *A. anthracinus* (p. 126, Lake Erie); *A. lamarii* (p. 139, Mississippi R.); *A. atelaspis* (p. 141, Saskatchewan R.); *A. rafinesquii* (p. 143, Ohio R.); *A. rosarium* (p. 152, Lake Erie); *A. platyrhinus* (p. 154, Upper Mississippi or Lake Erie); *A. kirtlandii* (p. 161, Lake Erie); *A. nortinianus* (p. 162, Michigan); *A. honneymani* (p. 177); *A. cincinnati* (p. 229, Ohio R.) and *A. buffalo* (p. 231, Lake Erie). Of these, all but the first four species and *A. rhynchaeus* appeared as new species. In a review of the North American acipenserids, Kirsch and Fordice (1889) (see annotation in this bibliography) listed all these species as

synonyms of the lake/rock sturgeon: "*Acipenser rubicundus*".

Dumont, P., and Fournier, N. 1987. Choix d'un engin de pêche pour la capture commerciale de l'esturgeon jaune dans le couloir fluvial. Qué. Minist. Loisir Chasse Pêche. Serv. L'ameng. L'expl. Faun. Mont. 5 p.

Data from experimental gill netting between 1983 and 1986 and harvest records from longlining were used to determine the type of fishing gear that should be used in the commercial fishery for lake sturgeon. The gear should target fish that weight over 3.1 kg and are greater than 800 mm in length and have a lower probability of capturing sexually mature females which typically weigh 15 kg, measure 1,330 mm and are 28 years old. The recommendations were that longlining should cease, as this type of gear caught larger fish than gill nets, and that commercial gill nets should have mesh sizes between 8 and 9 inches.

Dumont, P., Axelsen, F., Fournier, H., Lamoureux, P., Mailhot, Y., Pomerleau, C., and Portelance, B. 1987. Avis scientifique sur le statut de la population d'esturgeon jaune dans le syteme du fleuve Saint-Laurent. Plan de gestion de la pêche comite scientifique conjoint. Qué. Minist. Agric. Pêche. Aliment. iii + 21 p.

This report summarized the available data on the biology and commercial harvest of lake sturgeon in the Saint Lawrence River and the Montréal archipelago. The species is localized but there appeared to be a single population from Lac Saint-Louis to Lac Saint-Pierre. Commercial yields varied from 102.5 tonnes in 1983 to 138.8 tonnes in 1986 and were highest in lakes Saint-Louis and Saint-Pierre. The Lac Saint-Francois lake sturgeon population was decimated while the population in Lac des Deux Montagnes was being restored. Data were presented for annual catch records from 1963 to 1986. Over this period there were substantial increases in the catch from Lac Saint-Pierre and from the Saint Lawrence River downstream of Montréal. Recommendations included the protection of spawning females and a reduction in the fishing mortality of fish between 14 and 28 years of age.

Dumont, P., Fortin, R., Desjardins, G., and Bernard, M. 1987. Biology and exploitation of lake sturgeon (*Acipenser fulvescens*) in the Québec waters of the Saint-Laurent River, p. 57-76. In C. H. Oliver (ed.) Proceedings of a Workshop on the Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23.

Data were collected between 1981 and 1984 on the biology and commercial exploitation of lake sturgeon in the Saint-Laurent River from Lac St. Francois to Lac Saint-Pierre. The mark recapture experiment indicated that movements were restricted, except for rather extensive spawning migrations. From Lac Saint-Louis to Lac Saint-Pierre, sturgeon probably formed a single population and local differences in the length-weight relationship and harvest structure were probably related to variations in environmental and exploitation factors. Natural and fishing mortalities were high in all commercial fishing sectors and the annual legal harvest was over 100 tonnes. Yields varied from 1.4-3.4 kg/hectare. The Lac Saint-Francois fishery, which was isolated from the downstream fisheries, was depleted. Factors that enabled high yields to be sustained over many years included: the moderate biological activity of these waters, light exploitation of the large sectors, and the fact that commercial fishermen were selective in their use of gill-nets.

Dumont, P., Desjardins, G., Fortin, R., Fournier, N., Leclerc, J., and Bernard, M. 1988. L'esturgeon jaune, *Acipenser fulvescens*: biologie et exploitation dans les eaux du fleuve Saint-Laurent et de l'archipel de Montréal. Québec Ministère du Loisir, de la Chasse et de la Pêche, SAEF Montréal. Rapport technique 06-39: 78 p.

This document was not available for annotating.

Dumont, P., Lamoureux, P., Laforce, G., Haye, M.L., and Fournier, N. 1989. Influence de la dimension de l'hameçon sur la sélectivité et le rendement de la ligne dormante pour la capture de l'esturgeon jaune (*Acipenser fulvescens*). Avis Scientifique 89/1, Qué. Minist. Loisir, Chasse, Pêche. Minist. Agric. Pêche. Aliment. x + 35 p.

A longline fishing study was undertaken during 1987-88 to assess different hook sizes. The objective was to determine a hook size that would selectively catch an approximately 15 kg

fish (the size of females at first sexual maturity) but still allow some commercial harvest. There were diagrams of hooks ranging from 6/0 (largest) to 2/0 (smallest), an illustration of a set, and a map of the study area. Hook sizes of 6/0 and 3/0 were most used and most efficient in catching fish. The 3/0 hook was less likely to catch a sexually mature female than a 6/0 and was similar to gill nets of mesh size 19-20.3 cm. Illegal sized fish (3.1 kg) were more frequently caught with the 3/0 hook versus the 6/0. Length and weight frequency distributions of the catch for each of the hook sizes were presented. The authors suggested that stronger hooks and more frequent lifts would increase the catch of larger fish, but felt more work was needed to prove this conclusively.

Dumont, P., Leclerc, J., Mailhot, Y., Fortin, R., and Rochard, E. 2001. The evolution and management of the St. Lawrence River lake sturgeon (*Acipenser fulvescens*) stock, Québec, Canada. Prepared for the 4th International Sturgeon Conference, Oshkosh, WI. 5 p.

This document is an earlier version of Dumont *et al.*, 2006 (see in this bibliography).

Dumont, P., Leclerc, J., Mailhot, Y., Dumas, R., Broisebois, J., Dolan, D., Bourbeau, D., and Masse, H. 2002. Évolution de la force des classes d'âge de l'esturgeon jaune du fleuve Saint-Laurent de 1984 à 1998. Septième atelier sur les Pêches commerciales, Québec, 15-17 janvier 2002. 7 p.

Management of the commercial lake sturgeon fishery on the St. Lawrence Seaway is based on examining abundance data and population structure from the catch, and, since 1995, the recruitment of juveniles into the population. The data indicated that lake sturgeon had been overexploited since the mid 1970s. The objective of the study was to examine an index of relative recruitment of about fifteen St. Lawrence Seaway lake sturgeon cohorts based on data collected between 1991 and 1999, and 2001. Other objectives were to determine whether there were any changes in growth rates during these periods, and calculate a new relative recruitment index for the period 1984-1998. Year class strength was lowest for the periods 1984-1992 and 1996-1998, and highest between 1994 and 1995. The low recruitment rate in the commercial fishery will be observed at least until 2010-2015. The mean length at age

of juvenile lake sturgeon was very stable among years.

Dumont, P., Leclerc, J., Desloges, S., Bilodeau, P., Mailhot, Y., Dumas, R., La Haye, M., Verdon, R., and Fortin, R. 2005. The biology, status and management of lake sturgeon (*Acipenser fulvescens*) in the Québec part of the St. Lawrence River: a summary. Lake Sturgeon workshop, September 22-23, 2005, Cornwall, Ontario. 7 p.

This document is an earlier version of Dumont *et al.*, 2006 (see in this bibliography).

Dumont, P., Leclerc, J., Desloges, S., Bilodeau, P., Mailhot, Y., Brodeur, P., Dumas, R., Mingelbier, M., Verdon, R., La Haye, M., Morin, J., and Fortin, R. 2006. The biology, status and management of lake sturgeon (*Acipenser fulvescens*) in the Québec part of the St. Lawrence River: a summary. Presented at the Lake Sturgeon Recovery Planning Workshop, February 28 - March 2, 2006, Winnipeg, MB. 11 p.

The proceedings of this workshop are in preparation. The lake sturgeon population in the Québec part of Lake St. Francis, considered depleted in the 1940s, 1960s and 1980s, is still very low. This is due to the construction of dams at both ends of the lake between 1912 and 1958 and to overfishing. Lake sturgeon in the Québec portion of the St. Lawrence River show restricted movements except during spawning migrations. Large numbers of lake sturgeon occur in small localized areas, increasing their vulnerability to fishing gear and other human impacts. The main items in the diet of juvenile lake sturgeon are amphipods, aquatic insect larvae, molluscs and oligochaetes. Atlantic and lake sturgeon co-occur in the upper estuary of the St. Lawrence River. In this area, prey items are the same, but are consumed in different proportions. The lake sturgeon fishery in Québec, primarily commercial, was discussed. The 1999 commercial quota was 200 tons, and this was decreased by 40 tons per year (20%) for 2000, 2001 and 2002. Prior to 2000, the fishing season was June 14 to October 15; post-2000, the season was shortened by two months (July 31 to September 14). Reproduction, recruitment and habitat conservation were also discussed. It was noted that the largest known spawning ground in the Québec portion of the St.

Lawrence River was discovered in 2002, at the Lachine Rapids. Forty-seven references, many relating to Québec, were included.

Dymond, J.R. 1926. The Fishes of Lake Nipigon. Publ. Ont. Fish. Res. Lab. 27: 93 p. + app.

The physical nature of Lake Nipigon and its various bays was characterized, followed by an account of the fish species present in the lake. The external morphology of the lake sturgeon was described in taxonomic format, followed by a paragraph on its general biology. The sturgeon was said to be fairly common in Lake Nipigon and was found in the shallower bays such as Humboldt, Ombabika, Windigo and Gull bays. The species' diet in this lake consisted mainly of chironomid larvae, ephemeropterid nymphs and molluscs.

Dymond, J.R. 1947. Acipenseridae, p. 4. In A list of the freshwater fishes of Canada east of the Rocky Mountains. Royal Ontario Museum of Zoology, Misc. Publ. No. 1.

The geographical range of lake sturgeon in Canada was briefly mentioned, ranging east-west from Lake Champlain, St. Lawrence River to the Saskatchewan River (Alberta) and north-south from the Hudson Bay drainage to the Great Lakes.

Ead, S.A., Katopodis, C., Sikora, G.J., and Rajaratnam, N. 2004. Flow regimes and structure in pool and weir fishways. J. Environ. Eng. Sci. 3: 379-390.

This document examined the hydraulics of pool and weir fishways. It was noted that there were few existing fishways that targeted species larger or smaller than adult salmon. Lake sturgeon were listed as a species of concern with respect to fishway design in Ontario, Manitoba, Saskatchewan, Wisconsin, Michigan and Hokkaido, Japan.

Earle, S. 2002. Status of the lake sturgeon (*Acipenser fulvescens*) in Alberta. Alberta Wildlife Status Report 46: viii + 30 p. [Prepared for Alberta Sustainable Resource Development (SRD) and Alberta Conservation Association (ACA)]. Available from www3.gov.ab.ca/srd/fw/status/ [accessed 31 March 2006].

North American lake sturgeon populations have been adversely affected by overfishing, habitat fragmentation, water diversions, and pollution in the 20th century. Sturgeon are particularly vulnerable because of their long life cycle, delayed maturity, and infrequent spawning habits. Alberta lake sturgeon occurred at the westernmost portion of their North American range in the North Saskatchewan and South Saskatchewan rivers. From 1940 to 1968, commercial and recreational fishing of lake sturgeon was closed, only to be reopened for recreational fishing in 1969. By the year 2000, it was estimated that there were less than 200 mature sturgeon in the North Saskatchewan River. The most recent estimation for the South Saskatchewan River was roughly 500 mature fish in 1986. The mortality rates of lake sturgeon in this area appeared to exceed maximum sustainable levels, so the continuation of long-term studies to assess the Alberta populations was recommended.

Ebener, M.P. (ed.) 2005. The state of Lake Superior in 2000 (Draft). Gr. Lakes Fish. Comm. Spec. Publ. **2005-XX**. 130 p. + figures, tables.

The goal for lake sturgeon was to "Maintain, enhance and rehabilitate self-sustaining populations where the species historically occurred" (pg. 6). Historically, 21 tributaries of Lake Superior had spawning populations of lake sturgeon. At the time of writing, lake sturgeon were known to reproduce in 11 of these tributaries. Stocking of fingerlings in the St. Louis River and western Lake Superior had increased juvenile abundance. Hydroelectric facilities were the greatest problem facing lake sturgeon rehabilitation in 12 of the 21 historical spawning tributaries. Lake sturgeon recommendations were given as follows: 1) describe and quantify spawning, nursery and rearing habitat; 2) determine and maintain minimum required flows during the spawning season; 3) monitor harvest to determine population specific exploitation rates; 4) consider stocking implications on remnant stocks and develop a consensus on stocking efforts; and 5) to conduct standardized surveys to monitor lake sturgeon populations. The history of the fisheries of Lake Superior, the physical habitat, chemical contaminants in fish, phytoplankton, zooplankton, benthos and several other fish species were also discussed.

Echevarria, C. 2004. Lake sturgeon 2003 year class production (Region 4). United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

Echevarria, C. 2005. Lake sturgeon 2004 year class production (Region 4). United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

Eddy, S. 1945. Paddlefish and sturgeon. Geological relicts among Minnesota fishes. *The Conservation Volunteer* **8**: 29-32.

In this article, the author discussed the lake sturgeon in the context of the evolutionarily ancient fishes found in the world and the acipenseriformes in Minnesota. The lake sturgeon was one of the two acipenserids found in the waters of Minnesota, shovelnose sturgeon being the other. The differences between the two sturgeon, their food habits, and spawning behavior at the foot of Taylor Falls was described. Smoked flesh of both sturgeon were considered to be the best smoked fish available. Despite protective laws, sturgeon populations were on the decline and artificial propagation was viewed as having been largely unsuccessful.

Eddy, S., and Surber, T. 1947. Family Acipenseridae, the sturgeon family, p. 75-80. *In* Northern fishes, with special reference to the upper Mississippi Valley. The University of Minnesota Press, Minneapolis, Minnesota.

The sturgeon was regarded as the largest fish of the native fishes of Minnesota and neighboring states. Protective laws caused an increase in lake sturgeon populations from low levels prior to 1939, in the Snake, Cross and Kettle rivers, and in Lake Pokegama. Favorite spawning grounds included the Soo Rapids on Rainy River and the Cross Lake Dam upstream of the Snake River. Spawning migrations were observed as early as April 5, when the ice began to break, and lasted to the middle of June. Observations on the condition of ovaries of 40 fish sampled at the mouth of the Rainy River indicated that sturgeon spawned over a period of several months and deposited few eggs at a time at various locations.

Eddy, S., and Underhill, J.C. 1974. Family Acipenseridae, the Sturgeon Family, p. 125-131. In *Northern fishes*, with special reference to the upper Mississippi Valley. Third Edition. University of Minnesota Press, Minneapolis, MN.

In this account on lake sturgeon, the life history was briefly described and the decline in populations following early exploitation of the species was recounted.

Eggold, B., and Burzynski, T. 2004. Lake sturgeon rehabilitation in Lake Michigan, the Milwaukee River experience. In *Program and Abstracts*. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The authors reported on the early stages of a lake sturgeon rehabilitation program in the Milwaukee and Manitowoc rivers. Initial plans were to stock 2,800 fingerlings, 100 yearlings, and 100,000 larvae of the Lake Winnebago strain into the Milwaukee River, annually, with transfers from the Wolf River to supplement. PIT tags and radio tagging were to be used to identify population and life history needs, critical habitat, and barriers to migration.

Eigenmann, C.H. 1895. Results of explorations in western Canada and the northwest United States. *Bull. U.S. Fish. Comm.* (1894) **14**: 101-132.

On page 107, the author reported *Acipenser sturio*. This record appears as a synonym of the lake sturgeon, *Acipenser fulvescens*.

Elliott, R. 2003a. Status assessment of remnant lake sturgeon populations in the Lake Michigan basin. Progress report - January 2003. United States Fish and Wildlife Service, Sea Lamprey Control, 18 p.

This document was not available for annotating.

Elliott, R.F. 2003b. Lake sturgeon update for Lake Michigan. Minutes of the March 19-20, 2003 Lake Michigan Committee meeting. Great Lakes Fishery Commission, Upper Lakes Meetings, Milwaukee, WI. 10 p.

This document was not available for annotating.

Elliott, R. 2004a. Status assessment of remnant lake sturgeon populations in the Lake Michigan basin. Progress report - July 2004. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 12 p.

This document was not available for annotating.

Elliott, R.F. 2004b. Lake Michigan Lake Sturgeon Task Group report. Minutes of the March 24-25, 2004 Lake Michigan Committee meeting. Great Lakes Fishery Commission, Upper Lakes Meetings, Ypsilanti, MI. 11 p.

This document was not available for annotating.

Elliott, R. 2005a. Status assessment of remnant lake sturgeon populations in the Lake Michigan basin. Progress report - January 2005. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 19 p.

This document was not available for annotating.

Elliott, R. 2005b. Status assessment of remnant lake sturgeon populations in the Lake Michigan basin. Progress report - July 2005. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 18 p.

This document was not available for annotating.

Environmental Applications Group Limited. 1980. Onakawana site aquatic studies (fall 1979). Prepared for Ontario Hydro, Toronto, ON. Pagination unknown. [Unpublished].

This document was not available for annotating.

Environmental Applications Group Limited. 1981. Onakawana site aquatic studies - 1980. Prepared for Ontario Hydro, Toronto, ON. Pagination unknown. [Unpublished].

This document was not available for annotating.

Environmental Applications Group Limited. 1988a. Lake sturgeon culture techniques manual. Prepared for Ontario Ministry of Natural Resources, Northern Region, South Porcupine, ON. 108 p.

This manual contained information pertinent to the aquaculture of lake sturgeon. A variety of

areas were covered and the manual proceeded systematically through 11 chapters, from methods of sperm and egg collection and fertilization procedures to the actual rearing and feeding of hatched sturgeon. Various feeds and their efficacy were described. Eight spawning sites were appraised for their potential egg and milt collection. Information on the dates or duration of the spawning act was not available for most of the sites, nor was there substantial information on the spawning population in those areas. The potential problems associated with bacterial and fungal pathogens were mentioned. Various designs and costs for a hatchery were discussed. The three appendices in the reference section listed the names and addresses of principal sturgeon culturists, food supply contacts and hatchery equipment. The manual drew extensively from progress made on white sturgeon culture in California.

Environmental Applications Group Limited. 1988b. Lake sturgeon stocking plan. Prepared for Ontario Ministry of Natural Resources, Northern Region, South Porcupine, ON. 36 p.

The basis of stocking programs was identified as being the establishment of self-sustaining populations. Interestingly, the authors quoted unpublished information suggesting that the presence of a strong walleye population was an indication that habitats were suited for lake sturgeon. Stocking assessment was difficult since so few programs had been undertaken. Stocking with lake sturgeon 2.5-7.5 cm in length, at a density of about 20 fish/hectare, was recommended since the mortality rate of stocked fry was believed to be high. Feed costs were estimated at \$9 (Can.) per 454 g for tubifex worms at a feeding rate of 1.4 kg/2,500 fish/day. Diet conversion to artificial feeds was difficult and mortalities were high. Estimated costs to raise sturgeon fingerlings in Minnesota was approximately \$2.60 (Can.) while cost of fry was 1-2 cents/fish (capital cost of hatchery not included). Problems associated with levels of mercury in sturgeon flesh needed to be considered in stocking programs. Stocking of adults and subadults, from unexploited systems only, was suggested as a management strategy. Assessment should involve the marking and recapturing of marked fish to determine the success of stocking. Binary coded microtags injected into the cartilaginous cranium were considered to be a good tag. A mandatory head return program would be needed if a sport or

commercial fishery were involved in the area of release. Computer models were used to predict outcomes for a sturgeon stocking program. Predictions suggested that a combination of natural recruitment, adult transfers and natural recruitment would give the best returns and a "buy back" time of four years.

Environnement Illimité inc. 1994. Centrale Les Cèdres - Nouvel aménagement - phase 2 - Études environnementales. Concepts d'aménagement de frayères à esturgeon jaune et d'ouvrages de montaison. Report prepared for Hydro-Québec, Montréal, QC. ix + 98 p. + apps.

Plans for the construction of an artificial spawning ground in the section of the St. Lawrence Seaway between Pointe-des-Cascades and control structures at Coteau were discussed. Issues and strategies associated with the construction were addressed by examining fish distribution and reproductive potential along with water management in the different basins. Variable species richness has been observed among Saint-Louis Lake, and Saint-Thimothée and Les Cèdres basins. Important spawning habitat had been observed at Pointe-des-Cascades basin. Demand for construction of reservoirs by residents of Pointe-des-Cascades and Saint-Thimothée demonstrated the need for migratory passageways. Construction of an artificial spawning ground for lake sturgeon was proposed downstream of Beauharnois in an area where spawning fish are known to occur. An artificial river will be created parallel to Pointe-des-Cascades. In the first phase, a fish ladder will be used at floodgate 16 at Pointe-des-Cascades. The cost for the work was estimated by Hydro-Québec to be \$712,000 (1992 dollars). In the second phase, an artificial river on Ile-des-Cascades and ahead of the South-East spillway gates was proposed. An artificial lake sturgeon spawning ground will be created in an area used by sturgeon downstream of floodgate 14. The cost of the project was estimated at \$2,027,000 (1992 dollars). The construction of the artificial spawning ground with or without a fish ladder was considered as an alternative to the second phase. The cost of the spawning ground was estimated at \$575,000 (1992 dollars). The cost of a permanent fish ladder would have to be examined after analyzing the results of a study.

Environnement Illimité inc. 2003. Centrale de l'Eastmain-1-A et dérivation Rupert - Esturgeon jaune. Rapport sectoriel 2002-2003. Gendron, M., F. Burton, et G. Guay. Report submitted to Société d'énergie de la Baie James (SEBJ), Montréal, QC. 124 p. + 4 apps.

A study was conducted between 2002 and 2003 to collect baseline data on lake sturgeon spawning, feeding, and wintering habitats and population characteristics. A total of 186 adult and 41 juvenile sturgeon from the Rupert River were captured with experimental gill nets set and tagged with external transmitters (Advanced Telemetry Systems F2060 and F2050). Fish were tracked by helicopters outfitted with dual antennas and floating pontoons. Upon triangulation of an individual fish, the aircraft would land at the site on the river and record location, water temperature, depth, flow speed and substrate. Results demonstrated variable movement between spawning and feeding areas in both summer and fall for adults and juveniles, although juveniles covered less distances than adults. Adults preferred low flow areas (<0.4 m/s), depths less than 8 m and silt and sand dominated substrates in the summer, while in the winter areas of lower flow (<0.2 m/s) and deeper waters (2-16 m) were favored. Juveniles were located in areas of greater depth and higher velocities than adults in the summer and fall. Seventeen spawning grounds were located and generally consisted of boulders, cobbles and pebbles always without silt. The spawning grounds were between 0.4 and 1.25 m deep with flow velocities between 0.2 and 1.1 m/s. Results indicated the presence of 13 populations of lake sturgeon with high densities in most locations except below Lake Nemiscau and a section linked to the Eastmain and Opinaca Rivers and Lake Boyd.

Environnement Illimité inc. 2004a. Aménagement hydroélectrique de l'Eastmain-1 - Esturgeon jaune - Étude d'impact et aménagements. Version finale. Présenté à Hydro-Québec, Montréal, QC. iv + 32 p.

The Société d'Énergie de la Baie James built the Eastmain-1 generating station on the Eastmain River, upstream from the Opinaca reservoir in 2002. Studies were completed to collect lake sturgeon biological data, habitat characteristics and movement data in areas affected by the development before the filling of the reservoir. This report was an analysis of the effects of the

hydroelectric project and mitigation and compensation measures were presented. The most important potential impact was the loss of an 890 m² spawning site at the PK 215 area of the Eastmain River due to decreased water levels. Compensatory measures included the construction of three artificial spawning grounds situated at areas PK 203, PK 207 and the first rapid in the Eau Claire River. These three sites will be the only rapids accessible for lake sturgeon once water levels drop. The uncertainties regarding the suitable habitat for alevins on the artificial spawning grounds, and potential issues with variable flow rates will be mitigated by the removal of fertilized eggs, incubation and later release of approximately 60,000 alevins per year until natural production and recruitment are observed. The lower water levels between the PK 207 and PK 215 sections of the river will increase turbidity through increased erosion of areas that are predominantly clay and affect overwintering habitat for lake sturgeon. Water quality will be monitored and large stones placed at PK 207 to ensure higher water levels and winter habitat in the area. Spawning runs built in the Gipouloux River would ensure that spawners used the river. Introducing fertilized eggs and alevins in the T326-a6 tributary, a potential spawning ground located upstream from the Eastmain-1 reservoir, could initiate lake sturgeon production in the reservoir.

Environnement Illimité inc. 2004b. Aménagement hydroélectrique de l'Eastmain-1 - Caractérisation de la population d'esturgeon jaune. Rapport sectoriel 2002-2003. Burton, F., M. Gendron, G. Guay, and J. Gingras. Rapport présenté à la Société d'énergie de la Baie James (SEBJ), Montréal, QC. xii + 137 p. + apps.

The construction of a new generating station on the Eastmain River required a study on the lake sturgeon population in the affected area. Data was collected in 2002 and 2003 on lake sturgeon spawning, feeding, summer, and winter habitats from telemetry studies, sampling of adult and juvenile fish using gill nets, and eggs. A total of 125 adult and 17 juvenile lake sturgeon were tagged. It was confirmed that adult lake sturgeon can cover large distances as 17 adults moved of 100 km over the course of the study. The longest distances were achieved in the spring, between overwintering sites and spawning grounds, and during the summer

when fish moved towards feeding areas. Fish moved little during the winter. Lake sturgeon spawned in the Eastmain River between June 19 and 21 in 2002, at water temperatures between 14.5 and 15°C, and June 6 and 8 in 2003, at water temperatures between 11.5 and 12°C. Spawning fish were between 1 and 1.5 meters in length. Two important spawning sites were identified. The first was in the PK 215 section of Eastmain River and occupied an area of 890 m², and the other was located in the PK 62 section of the Opinaca River. Spawning habitat was characterized as a shoal consisting of various substrate types (boulders, gravel, and cobble) without silt, sand and organic materials. Adult and juvenile lake sturgeon overwintered at depths between 6 and 8 m and water velocities of 0.2 m/s.

Environnement Illimité inc. 2005. Centrale de l'Eastmain-1-A et dérivation Rupert - Étude complémentaire sur l'esturgeon jaune 2004. La Haye, M. et M. Gendron. Rapport présenté à la Société d'énergie de la Baie James (SEBJ), Montréal, QC. vii + 55 p. + apps.

A study was conducted on lake sturgeon from the Rupert River in order to determine fish habitat use in the area that is affected by the Eastmain-1-A generating station and the river diversion. An objective of the study was to examine spawning and use of spawning habitat of lake sturgeon, walleye and suckers from the Rupert River. Rupert Bay lake sturgeon movements were monitored by telemetry and an exploratory fishery was carried out in the Opinaca River. On a known spawning ground at the PK 216 section of the river, large lake sturgeon were observed between June 6 and 8 at a water temperature of 10°C. Spawning behaviour was noticed among a concentration of mature lake sturgeon June 12-14 while the water temperature was between 12.1 and 12.9°C. Two spawning sites, one covering an area of 12,650 m² and the other 1,875 m², are located at PK 216. In the spring of 2003, 12 lake sturgeon spawners were tagged and followed in the summer, fall and winter. Tagged fish were also followed in the spring of 2004. Over the winter, fish were present in the Rupert, Broadback and Nottaway Rivers. In the spring, 4 lake sturgeon went up to the PK 23 section while others went to the mouth of the Nottaway River and near Rupert Bay. In the summer, lake sturgeon migrated to feeding grounds.

Erickson, S. (ed.) 1998. Masinaigan Supplement. A publication of the Great Lakes Indian Fish & Wildlife Commission, Odana, WI, Spring: 16 p.

The history of the Ojibwe [Ojibwa, Ojibway] people at Kabapikotawangag (Lake of the Woods), as it relates to Numae (lake sturgeon) and treaty rights, was recounted through a series of articles. Article titles included: The historical significance of numae; Kabapikotawangag Chiefs launch treaty rights enforcement action; Legal action against Canada's aboriginal fishing strategy; Recent Canadian Supreme Court decisions relating to treaty rights; The history of Treaty #3-Northwest Angle Treaty of October 3, 1873; The Paypom Document; Order in Council notes depletion of fishery; Conflicts over Fisheries on Lake of the Woods; 1873-1909; Demand for Lake of the Woods caviar in 1895; Use of sturgeon products in 1905; Conflicts continue: 1910-1960; and Recent bad Faith: 1986 to present.

Erickson, S. 2000. Joint effort pumps lake sturgeon into Bad River system. Mazina'igan, A Chronicle of the Lake Superior Ojibwe, Odana, WI, Summer: Pagination unknown. Available from <http://www.glifwc.org/pub/summer00/sturgeon.htm> [accessed 31 March 2006].

Lake sturgeon stocking in the Bad River on the Bad River reservation was discussed. A total of 23,000 sturgeon fry were stocked into the river over a two week period in May of 2000. Stocking was planned to continue throughout the summer.

Erickson, S. (ed.) 2004. Seasons of the Ojibwe. 2004 Edition. Great Lakes Indian Fish & Wildlife Commission, Odana, WI. 52 p. Available from www.glifwc.org/pub/seasons.htm [accessed 31 March 2006].

A project of the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), the Bad River Natural Resources Department and the USFWS was briefly discussed on page 27. The goal was to gather information on the distribution and movements of juvenile lake sturgeon in the Bad River system of Wisconsin, which supports one of four known lake sturgeon spawning populations in Lake Superior tributaries. The population has been increasing over the past nine years of study.

ESG International Inc. and Nassagaweya Environmental Consultants Ltd. 2003. Lake sturgeon population study, 2002, Little Long Reservoir, Mattagami River. Prepared for Ontario Power Generation, Guelph, ON. Pagination unknown.

This document was not available for annotating.

Eshenroder, R.L., Holey, M.E., Gorenflo, T.K., and Clark, R.D., Jr. 1995. Fish-community objectives for Lake Michigan. *Gr. Lakes Fish. Comm. Spec. Publ.* **95-3**: 58 p. Available at www.glfc.org/pubs/SpecialPubs/Sp95_3.pdf [accessed 31 March 2006].

At the time of first contact between aboriginals and Europeans in the Lake Michigan basin, aboriginals were harvesting a variety of species, including lake sturgeon, with nets made of nettles, spears, hook and line, and weirs in streams. By 1879, sturgeon were reported as being commercially fished.

Evans, R. 1990. Mattagami River plant extensions: summary of impacts on aquatic biology. Ontario Hydro, Environmental Studies and Assessments Department, Toronto, ON. 33 p. [Unpublished].

This document was not available for annotating.

Evans, R.R., Parker, B.J., and McCormick, B.J. 1993. Strategy assessment - sturgeon stranding in Adam Creek. Ontario Hydro, Northern Development Department Report No. **935013**: iv + 14 p.

Agreements on how to manage sturgeon stranding below the proposed Mattagami River Hydroelectric Extensions were discussed in this report. When the control structure was shut, lake sturgeon were stranded below it, in pools along the dewatered diversion channel. Results of studies to determine the extent of sturgeon stranding showed that there was either wide variance in the number of sturgeon entrained from year to year, or fish collected in 1990 were the result to several years of accumulated entrainment. Several methods of approaching the problem were proposed, but short-term physical relocation of sturgeon was preferred until further investigation of the problem was completed. Further monitoring of the situation and the development of a long-term solution were recommended.

Evermann, B.W., and Latimer, H.B. 1911. The fishes of the Lake of the Woods and connecting waters. *Proc. U.S. Natl. Mus.* **39**: 121-136.

Lake sturgeon were discussed under the name Great Lakes Sturgeon (*Acipenser rubicundus*), and commercial harvest statistics from 1888 to 1909 were summarized and discussed. The authors suggested a minimum commercial size of 20 pounds dressed weight, and noted that a four foot long sturgeon would be too small, as it would only weigh about 15 pounds dressed. The main spawning area was given as Rainy River. This may have been the only known spawning ground at the time. In the United States, the commercial harvest peaked at 1.3 million pounds in 1803. Commercial harvest dropped to 34,021 pounds by 1909. In Canada, commercial harvest peaked at 500,000 pounds in 1804 and 1805. This fell to 19,395 pounds by 1909. Lake sturgeon diet consisted mainly of crawfish and smaller gastropods. The International Fisheries Commission recommended an end to sturgeon fishing in this area for a period of four years.

Fago, D. 1984. Distribution and relative abundance of fishes in Wisconsin. III. Red Cedar River Basin. Wisconsin Department of Natural Resources Technical Bulletin **143**: 69 p.

The lake sturgeon was listed on page 11 as a "Watch Species". This is an unofficial designation indicating that monitoring is required to assist in maintaining their survival in the area. Map 4 identifies areas where lake sturgeon had been collected in Wisconsin.

Fajfer, S., Meyers, L., Willman, G., and Carpenter, T. 1997. Growth performance of juvenile lake sturgeon as affected by rearing density, p. 459. *In* Managing Natural Resources: Integrating Ecology and Society, 59th Midwest Fish and Wildlife Conference, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Fajfer, S., Meyers, L., Willman, G., Carpenter, T., and Hansen, M.J. 1999. Growth of juvenile lake sturgeon reared in tanks at three densities. *N. Am. J. Aquac.* **6**: 331-335.

The objective of this study was to determine if rearing densities in hatcheries affected growth. Juvenile lake sturgeon (106 days old) were reared at three densities, 150, 300, and 450

fish/m² for 5 weeks. Feeding rates of fish fed chironomid larvae, brine shrimp, and euphausiids ranged from 15% to 34% body weight per day and varied with water temperature and diet. Patterns and changes in weight and length did not differ significantly among the three rearing densities. The authors concluded that all three rearing densities were acceptable for lake sturgeon.

Farbridge, K.J., and Leatherland, J.F. 1991. The development of a noncompetitive enzyme-linked immunosorbent assay for oncorhynchid growth hormone using monoclonal antibodies. *Gen. Comp. Endocrinol.* **83**: 7-17.

Monoclonal antibodies (MCAs) were generated by the fusion of myeloma cells with spleen cells from mice that were immunized with chum salmon (*Oncorhynchus mykiss*) recombinant growth hormone (GH). These were used in the development of a sensitive and specific two-site, noncompetitive enzyme-linked immunosorbent assay (ELISA) for oncorhynchid GH. The ELISA recognized GH plasma of rainbow trout, coho salmon, lake sturgeon, and bowfin. The sensitivity of the ELISA was less than 1.56 ng/ml.

Farr, R., North, J., and Rien, T. 1994. White sturgeon sampling techniques in the lower Columbia River impoundments, p. 11. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Faucher, R. 1999. Projet de réfection de la centrale La Gabelle - Aménagement d'une frayère pour l'esturgeon jaune. Bilan des travaux - 1999. Rapport présenté à Hydro-Québec par GDG Conseil inc., Montréal, Québec. i + 10 p. + apps.

This report summarized the construction method of 30 small artificial spawning sites for sturgeon below the La Gabelle generating station. The work occurred during the month of August, 1999, at a cost of \$59,850. An excavator was used to create a path out into the river. Each series of spawning sites measured approximately 1 m in height and 3 m in width, and consisted of several large boulders (1-3 m³) with finer materials placed just downstream. The excavator was accompanied by an experienced biologist who directed the placement of the

stones and boulders. The existing spawning grounds occupied an area of 3,000 m² and the new spawning grounds added 2,100 m² of spawning habitat, an increase of 50%. Twenty-five of the sites were placed in the centre of the river where most lake sturgeon activity was observed. The variety of materials used made it possible for other fish species to use the new spawning grounds.

Faust, E.C. 1918. Studies on American Stephanophialinae. *Trans. Am. Microsc. Soc.* **37**: 183-198.

Faust described the parasite *Acrolichanus petalosa* (Lander), based on specimens collected from lake sturgeon. Material from *Ambloplites rupestris* was also included in the description. Morphometrics included: Body = 1.5-2.5 x 0.32-0.54 mm; oral sucker = 0.27-0.45 mm; acetabulum = 0.16 x 0.32 mm in cross section; eggs = 70-72 x 40-50 µm. Other morphological features were also described. A key was provided for the Stephanophialinae.

Fedoruk, A.N. 1971. Sturgeon family (Acipenseridae), p. 35-36. *In* Freshwater fishes of Manitoba: checklist and keys. Manitoba Department of Renewable Resources and Transportation Services, Winnipeg, MB.

The lake sturgeon appeared in figure 16 on p. 36. Characteristics include an up-turned tail fin, no scales but bony plates, a mouth posterior to the front of the eye, and 4 barbells or "whiskers".

FERC (Federal Energy Regulatory Commission). 2000. FERC notice of availability of final environmental assessment and final EA for hydropower licenses - Petenwell and Castle Rock project (FERC project no. 1984-056), Prairie du Sac (Project No. 11162-002). 24 p.

This document was not available for annotating.

FERC (Federal Energy Regulatory Commission). 2004a. Environmental assessment for hydropower licensing - De Pere hydroelectric project, FERC project no. 4914-010. 29 p.

This document was not available for annotating.

FERC (Federal Energy Regulatory Commission). 2004b. Notice of availability of environmental assessment and environmental

assessment City of Norway, Michigan Sturgeon Falls hydroelectric project Michigan/Wisconsin, FERC project no. 2720. 46 p.

This document was not available for annotating.

Ferguson, M. 2000. Conservation genetics of lake sturgeon in central Canada, p. 9-10. In C. Lowie (ed.) Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization. Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **2000-01**. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 03 April 2006].

Ferguson, M.M., and Duckworth, G.A. 1997. The status and distribution of lake sturgeon, *Acipenser fulvescens*, in the Canadian provinces of Manitoba, Ontario and Québec: a genetic perspective. *Environ. Biol. Fishes* **48**: 299-309.

Mitochondrial DNA (mtDNA) analysis indicated that the majority of the 396 lake sturgeon sampled were one of two haplotypes. The majority of the samples from the Great Lakes/St. Lawrence and Mississippi drainage basins were of a single haplotype, and those of the Hudson/James Bay system were of both haplotypes. These results suggested that fish from the Missourian refugium may have recolonized the Hudson/James Bay drainage system, while those from the Mississippian refugium recolonized the Great Lakes/St. Lawrence region. Commercial overexploitation and habitat alteration by hydroelectric power facilities assisted in the reduction and extirpation of some populations. The largest zone of reduction and extirpation had occurred in the Lake Winnipeg drainage basin. Reduced populations have also been noted in Lake Ontario, Lake Erie and northern Ontario's fragmented waterways. Québec appeared to have placed the most emphasis on reducing stresses on lake sturgeon.

Ferguson, M., Bernatchez, L., Gatt, M., Konkle, B., Lee, S., and Malott, M. 1993. Population genetics of lake sturgeon (*Acipenser fulvescens*) in the Moose River basin, Ontario. Prepared for Ontario Hydro. University of Guelph, Guelph, ON. 43 p.

This document was not available for annotating.

Ferguson, M.M., Bernatchez, L., Gatt, M., Konkle, B.R., Lee, S., Malott, M.L., and McKinley, R.S. 1993. Distribution of mitochondrial DNA variation in lake sturgeon (*Acipenser fulvescens*) from the Moose River basin, Ontario, Canada. *J. Fish Biol.* **43**: 91-101.

Mitochondrial DNA (mtDNA) of *Acipenser fulvescens* was analyzed from the Moose River drainage basin. The fish were of two haplotypes based on restriction fragment length polymorphism analysis with 40 restriction endonucleases and direct sequencing of 275 nucleotides in the mtDNA control region. Fish from one tributary displayed different haplotype frequencies from other tributaries, suggesting they were from a discrete genetic stock. No haplotype genetic frequency heterogeneity in mtDNA was detected from sites within rivers, including those with hydroelectric structures. Gene flow amongst sites must therefore have been significant. The conservation of lake sturgeon was discussed in light of these findings.

Ferreiro, C., Medrano, J.F., and Gall, G.A.E. 1989. Genome analysis of rainbow trout and sturgeon with restriction enzymes and hybridization with ZFY gene derived probe to identify sex. *Aquaculture* **81**: 245-251.

This study evaluated screening methods for determine the sex of rainbow trout (*Salmo gairdneri*) and sturgeon (*Acipenser transmontanus*). For sturgeon, sex cannot be physically determined until the age of 4. The authors looked for repetitive DNA sequences possibly associated with the Y-chromosome and evaluated the use of a specific DNA code from humans (pdp1007) that detects a single copy sequence on the Y-chromosomes of mammals. All restriction enzymes used resulted in 1 to 9 distinct bands, indicating that large numbers of repetitive regions exist in trout and sturgeon DNA. The banding patterns were the same for males and females for all enzymes tested. Sex could not be determined with the enzymes used, but the approach still appeared promising. Lake sturgeon are not mentioned.

Findeis, E.K. 1997. Osteology and phylogenetic interrelationships of sturgeons (Acipenseridae). *Environ. Biol. Fishes* **48**: 73-126.

Skeletal characteristics were examined in *Huso*, *Acipenser*, *Pseudoscaphirhynchus*, and *Scaphirhynchus*, and in their outgroups, Polyodontidae, Peipiaosteidae, and Chondrosteidae. A total of 69 characters were identified to support the first generic level cladogram of Acipenseridae. *Huso* was phylogenetically primitive within Acipenseridae. *Acipenser* was not supported by any of the characters. The tribe Scaphirhynchini comprised of *Scaphirhynchus* and *Pseudoscaphirhynchus* was monophyletic. The resulting cladogram did not agree with previous concepts of acipenserid evolution. *Huso* defined an outgroup morphology and life history based on pelagic habitats and piscivory. Acipenserines and scaphirhynchines were benthic predators having characters used for benthic feeding, respiration, locomotion, and protection. Peramorphosis appeared to play a central role in the evolution of acipenserids. Peramorphic addition and enlargement of the skeleton and scalation defined most characters at all nodes of the acipenserids.

Findlay, C.S., Lagarec, D., McGillivray, R., Houlahan, J., and Sawada, M. [1994?] An assessment of the risks to lake sturgeon (*Acipenser fulvescens*) in the vicinity of The Pas, Manitoba. Preliminary Interim Report. University of Ottawa, Ottawa, ON. 21 p. + app.

Evidence for historical changes in a lake sturgeon population near The Pas, Manitoba was evaluated. The study area, consisting of the Saskatchewan River basin, was described in detail. Historical changes in abundance were analyzed using commercial harvest statistics for the area. Historical data were used to look for changes in age structure and growth. The authors found that lake sturgeon at Cumberland House showed a decreased growth rate after 1965/66 compared to pre-1965/66 levels. This decreased growth rate could still be seen in the 1980/82 sample. Potential stressors were identified through a questionnaire sent to members of the Opaskwayak community. Major hydroelectric dams, minor dams, dikes and water control gates, spread of wild rice, water pollution, pelicans, and over fishing were identified as potential stressors. The impact of hydroelectric dams was examined.

Finnley, D. (ed.) 1978. Missouri's "Design for Conservation" plan is broadening E.S. protection: more habitats being acquired. USFWS Endangered Spec. Tech. Bull. 3: 4-6.

This report highlighted certain endangered and vulnerable species of Missouri and studies being initiated or carried out with these species under Missouri's endangered species program. The brief account on lake sturgeon attributed the collapse of the state's sturgeon population to overfishing and poor management. The status of the pallid sturgeon was also discussed.

Flint, R.W. 1985. Biological control as a management strategy in the Great Lakes. J. Wash. Acad. Sci. 75: 85-90.

This paper discussed the use of natural biological systems to control aquatic weeds and sea lamprey in the Great Lakes. The author recommended the use of crayfish to control aquatic weeds, and the use of lake sturgeon to control sea lamprey through predation.

Fogle, N.E. 1975. Michigan's oldest fish. Mich. Nat. Res. 44: 32-33.

This popular article, accompanied by one of the few colour photographs of a live sturgeon, described the general life history of the lake sturgeon. The standing Michigan record was 193 pounds, 87 inches long with a girth of 40 inches, speared from Mullet Lake in February, 1974 by Joe Maka.

Folz, D.J., and Meyers, L.S. 1985. Management of the lake sturgeon, *Acipenser fulvescens*, population in the Lake Winnebago system, Wisconsin, p. 135-146. In Binkowski, F. P. and S. I. Doroshov (eds.) North American Sturgeons: biology and aquaculture potential. Dr. W. Junk Publishers, Dordrecht.

Management objectives were to limit harvest to maintain a sustained yield. The history of the system included a moratorium on fishing from 1915 to 1931. A spear fishing season was started in 1932. An extensive research/management program was conducted on the lake sturgeon from 1955 to 1967 on the biology, recruitment, and harvest of the population. A winter spear fishery was the only legal means to harvest lake sturgeon in the Winnebago system. From 1975 to 1983, 3,380 lake sturgeon were marked at spawning sites and netting of lake sturgeon in Lake Winnebago resulted in an additional 2,826 being marked. Spawning sites were created by placing riprap on the outside bends of tributary rivers. Each fish caught by spear fishing was registered and

total length, weight, location, date, and tag number were recorded. Trap nets and otter trawls were used in Lake Winnebago to remove freshwater drum. Sturgeon caught during this program above 114 cm in length were tagged (monel self-piercing cattle ear tag size 681 and 62, applied at the base of dorsal fin) and released. Density estimates were based on marking and recovery through registration of all sturgeon caught and use of the Peterson mark-recapture formula as modified by Bailey. Spawning sites were divided into major (more than 20 fish captured each year), minor (less than 20 fish captured), and not utilized each year. A total of 18,075 sturgeon were legally harvested in Lake Winnebago from 1955 to 1983. In 1974, the minimum length was increased from 102 to 114 cm in order to reduce the harvest by 11% and bring it in line with the estimated recruitment of 540 fish. Lake sturgeon were fully recruited to the harvest by age 16 and few remained above age 36. Lake sturgeon spawned in the Fox and Wolf rivers from mid April to early May. From 1975 to 1983 spawning activity occurred over 4 to 10 days with peak activity usually over 2-3 days. Spawning was initiated at 11.7°C, but was also noted at 14 to 16°C. The mean length of spawning females was 160.3 cm (range 129.5 to 200.7 cm) and mean length of males was 133.4 cm (range 82.6 to 175.3 cm). It was suggested that a shorter season for spear fishing may be more effective for fishery management than increasing the length limit. Netting operations from 1975 to 1983 noted a decline in the mean size. This was not due to a decline in the catch, but rather an increase in numbers of smaller sized sturgeon. The population was estimated at 24,600 and recruitment was estimated at 6.3% with a harvest of 2.5%. Fresh riprap spawning sites may be preferred as older sites become covered by silt, debris and algal growth. The final suggestion was to manage the spear fishery as a trophy fishery.

Folz, D.J., Czeskleba, D.G., and Thuemler, T.F. 1983. Artificial spawning of lake sturgeon in Wisconsin. *Prog. Fish-Cult.* **45**: 231-233.

This paper discussed efforts to spawn, fertilize and rear lake sturgeon without sacrificing the adults. The first attempt to obtain ripe adults was made in the spring of 1978. Sperm, extracted by palpation and drawn into a syringe, was stored in glass vials on ice. Caesarean sections were used to obtain free eggs which flowed from the

body cavity. Eggs were placed in a wet plastic pan and sperm was added. Water was then added, and the mixture stirred and allowed to stand for 2-3 minutes. A bentonite clay suspension was introduced to the pan to counteract the adhesiveness of eggs. Sperm from some males were viable after 22 hours of storage on ice. Hatching percentage ranged from 34-92. The paper listed 14 separate occasions of artificial fertilization and all studies were carried out on the Wolf River. The paper also briefly mentioned a radio-tracking study done on an individual female sturgeon implanted with a transmitter. The individual was followed for two years and appeared healthy when eventually recaptured.

Fontana, F. 1994. Chromosomal nucleolar organizer regions in four sturgeon species as markers of karyotype evolution in *Acipenseriformes* (Pisces). *Genome* **37**: 888-892.

The number and chromosomal localization of nucleolar organizing regions (NORs) in the karyotypes of *Acipenser ruthenus* ($2n = 118 \pm 4$), *A. baeri* ($2n = 246 \pm 8$), *A. transmontanus* ($2n = 248 \pm 8$), and *A. naccarii* ($2n = 246 \pm 8$) were examined. The NORs of *A. ruthenus* are localized in the telomeric regions of two morphologically different pairs of chromosomes, and the number of NORs is four. In the remaining three species, the 8 NORs are localized on eight chromosomes arranged in two groups of four. Based on these results the authors suggest that species with 120 chromosomes should be considered diploids and species with 240-250 chromosomes should be considered tetraploid. Lake sturgeon are not mentioned.

Fontana, F., Bruch, R.M., Binkowski, F.P., Lanfredi, M., Chicca, M., Beltrami, N., and Congiu, L. 2004. Karyotype characterization of the lake sturgeon, *Acipenser fulvescens* (Rafinesque 1817) by chromosome banding and fluorescent in situ hybridization. *Genome* **47**: 742-746.

Karyotype organization was investigated in lake sturgeon using C banding, fluorochrome and silver staining techniques. Fluorescent in situ hybridization (FISH) was also used to localize the *HindIII* satellite DNA family, the telomeric sequence (TTAGGG)_n, and the 5S rRNA genes. The mean chromosome number of the lake

sturgeon was $2n = 262 \pm 6$. Karyotype reconstruction showed the chromosomes are arranged in three groups in order of decreasing length. The three groups consist of the meta-submetacentrics (67 pairs), telo- and acrocentrics (35 pairs), and microchromosomes (60 in total). C banding showed the constitutive heterochromatin is variably distributed among chromosomes and microchromosomes. The *HindIII* satellite DNA probe revealed the clear presence of hybridization signals visible as centromeric heterochromatin blocks on 49 chromosomes. The telomeric repeat sequence (TTAGGG)_n was revealed by FISH and appeared as dot pairs at both ends of all chromosomes and two chromosomes were completely marked. Silver staining allowed the detection of active nucleolar organizer regions (NORs) on 12 chromosomes. These results are compared to those for other sturgeon species. The authors conclude that the lake sturgeon is likely a tetraploid species.

Forest Preserve District of Cook County (Illinois). 1978. The Sturgeons. Nature Bulletin 663-A: 2 p. Available from <http://www.newton.dep.anl.gov/natbltn/600-699/nb663.htm> [accessed 3 April 2006].

This document provided a general physical description of sturgeon and discussed threats to lake sturgeon and human uses. The largest lake sturgeon recorded from Lake Michigan was killed by a boat propeller in 1943. The fish was 7 feet, 11 inches in length and weighed 310 pounds. Another lake sturgeon, weighing 215 pounds, was 152 years old when it was caught in 1953. Human uses include eating the smoked flesh, caviar, isinglass produced from dried air bladders and used to clarify wines and beer, oil from the fat, glue from the skeleton and ornamental leather from the skins.

Forsythe, P., Scribner, K., Bott, K., and Baker, E. 2004. Fertilization success, egg predation, deposition and post emergent survival in the lake sturgeon: the relative importance of potential barriers to recruitment. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Low natural recruitment by lake sturgeon could be due to high rates of egg predation and low fertilization rates. This study estimated fertilization rates as a function of spawner

number and sex ratio, examined egg deposition, and determined the sources and degree of egg predation before larval emergence. Results showed a high degree of heterogeneity in egg deposition, high invertebrate predation, and interannual variability in post-emergent recruitment to the larval stage.

Forsythe, P.S., Scribner, K.T., Bott, K., Smith, K., and Baker, E. 2005. Spawning stock characteristics, egg deposition and post emergent survival in the lake sturgeon (*Acipenser fulvescens*): the relative importance of potential barriers to recruitment. Second Great Lakes Lake Sturgeon Coordination Meeting, November 9-10, 2004, Sault Ste. Marie, Michigan. 20 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 3 April 2006].

Fortin, R., D'Amours, J., and Thibodeau, S. 2002. Effets de l'aménagement d'un nouveau secteur de frayère sur l'utilisation du milieu en période de fraie et sur le succès de reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à la frayère de la rivière des Prairies. Rapport synthèse 1995-1999. Pour l'Unité Hydraulique et Environnement, Hydro-Québec et la Société de la faune du Québec, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie. Département des Sciences biologiques, Université du Québec à Montréal. xiv + 131 p. + map.

The surface area of an existing spawning ground downstream from the Rivière-des-Prairies generating station was increased by 8000 m² in 1996. This report synthesized results of studies done between 1995 and 1999 to examine the effect of the new spawning grounds on the reproduction of lake sturgeon. Spawning occurred in early May in 1998 and 1999 and in mid to late May in 1995-1997. Springs with lower water flows resulted in the capture of lower numbers of spawners in the southern portion of the river. The artificial spawning ground was widely used for egg deposition in 1996 and 1999 even during lower flow conditions. The area of the spawning ground near a canal built in 1996 was also used by lake sturgeon indicating that the canal did not have any negative effects on spawning activity. Recapture studies estimating the abundance of spawners varied between 9,657 (1,135 females) in 1996, and 4,163 (500

females) in 1999. The low number of females was noted as a concern. Results from larval drift studies indicated that the new section of spawning ground had a positive impact on lake sturgeon reproduction in the des-Prairies River.

Fortin, R., Dumont, P., and Guénette, S. 1996. Determinants of growth and body condition of lake sturgeon (*Acipenser fulvescens*). *Can. J. Fish. Aquat. Sci.* **53**: 1150-1156.

Lake sturgeon from 32 river systems were examined to identify determinants of variations in growth (length) and body condition. Growth was found to decrease with mean annual air temperature and latitude, and was generally faster in the west than the east. A multi-variate model incorporating latitude and longitude explained a greater proportion of the variation in growth. Condition decreased with latitude in the east and was relatively stable in the west. pH was the best individual predictor of condition.

Fortin, R., Dumont, P., Mongeau, J.R., Leveille, M., Guenette, S., and DesJardins, G. 1991. Distinction des stocks d'esturgeon jaune (*Acipenser fulvescens*) du Lac des Deux Montagnes et du couloir fluvial du Saint-Laurent au moyen de l'étude des déplacements, de la croissance et de la mortalité, p. 295-313. In P. Williot (ed.) *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989. Bordeaux, France.

Lake sturgeon populations of the two water bodies named in the title were investigated. Movements, growth, and total mortality were compared.

Fortin, R., Guénette, S., and Dumont, P. 1992. Biologie, exploitation, modélisation et gestion des populations d'esturgeon jaune (*Acipenser fulvescens*) dans 14 réseaux de lacs et de rivières du Québec. Québec, Ministère du Loisir, de la Chasse et de la Pêche, Service de l'aménagement et de l'exploitation de la faune et Service de la faune aquatique, Montréal et Québec. xxi + 213 p.

This document aimed to rationalize and harmonize lake sturgeon commercial fisheries in Québec. Information on lake sturgeon biology and exploitation was reviewed. Much of the information can be accessed through an

electronic database. The biological data includes growth, sexual maturity, spawning, sex ratio, fecundity, mortality (total, natural, and fishing), stock homogeneity, and also the importance, features and quality of spawning grounds. Fourteen management units (11 exploited and 3 unexploited) were created based on the biological characteristics of populations between the St. Lawrence Seaway and the La Grande complex. The fisheries statistics provided information on monthly and yearly landings along with the selectivity of fishing gear. Data from various lake sturgeon fisheries along with modeling results enabled the assessment of the exploited stocks and a test of the effectiveness of the management plan for that fishery. The document concluded with recommendations from a workshop attended by fishery managers, namely: 1) revising harvest management through closure of certain fisheries, and adjusting quotas, fishing seasons, size limits, and fishing methods; 2) following up on harvests; 3) fighting poaching; 4) protecting and restoring spawning and nursery habitats; and 5) the need for biological information.

Fortin, R., Mongeau, J.-R., Desjardins, G., and Dumont, P. 1993. Movements and biological statistics of lake sturgeon (*Acipenser fulvescens*) populations from the St. Lawrence and Ottawa River system, Québec. *Can. J. Zool.* **71**: 638-650.

Lake sturgeon movements and biological statistics were compared between Lac Saint-Louis, Lac Saint-Pierre, and Lac des Deux Montagnes, of which the first two were commercially fished. Lac des Deux Montagnes differed from the other two in that the fish tended to be more sedentary, grew slower, and had a lower condition factor. Some movement between Lac Saint-Louis and Lac Saint-Pierre was observed. Sturgeon tagged on the Rivière des Prairies and Rivière L'Assomption spawning grounds and pre- and post-spawning grounds were recaptured throughout the St. Lawrence River. Length, weight, and age of the commercial catch, growth, and total mortality varied between Lac Saint-Louis and Lac Saint-Pierre. Management concerns arising from these results were discussed.

Francis, G.R., Magnuson, J.J., Regier, H.A., and Talhelm, D.R. (ed.) 1979. Rehabilitating Great Lakes ecosystems. *Gr. Lakes Fish. Comm. Tech. Rep.* **37**: 99 p. Available from

www.glf.org/pubs/TechReports/Tr37.pdf
[accessed 3 April 2006].

The feasibility of rehabilitating the Great Lakes ecosystem was considered and deemed possible. Stresses on critical ecosystems within the lakes were addressed. The authors mentioned lake sturgeon as being a member of fish associations dominated by large species in the 1800s. An estimated 50% of the biomass of all fish in the lakes consisted of those weighing over 5 kg. The 1977 comparable proportion has been drastically reduced. The conditions of the Great Lakes roughly 200 years ago were discussed and contrasted against current conditions in the lakes. Several recommendations were made regarding the rehabilitation of the Great Lakes ecosystems.

Fraser, E.A. 1927. Observations on the development of the pronephros of the sturgeon, *Acipenser rubicundus*. Q. J. Microsc. Sci. **71**: 75-112.

Sturgeon embryos from 76 hours to 30 days after fertilization were examined for the development of the pronephros. The origin of the duct and canal could not be observed as these arise 51 hours after fertilization. The following stages post-fertilization were described: 76 hrs, 88 hrs, 100 hrs, 112 hrs, 6-7 days, 9 days, 12 days, 14 days, 20 days and 28 days. Embryos at 76 hrs possessed 6 short pronephric canals opposite somites 4-9. These canals emptied laterally into the pronephric duct. This was followed by the appearance of a tubule opposite somite 10. Thereafter the nephrotomes IV, V and VI opened into the splanchnocoel, nephrotome IV disappeared, and the first tubule opened dorsally into the second. The posterior nephrotomes became completely enclosed by the formation of a new ventral wall giving rise to a series of pronephric chambers. This was followed by development of the glomeruli with an accompanying disintegration of the walls separating the pronephric chambers. This resulted in the formation of a single elongated chamber containing a glomus. The pronephros reached its full development a few days after the embryo hatched, 9 days post-fertilization. It consisted of a single external nephrostome with 5-6 internal nephrostomes connecting the duct with an elongated pronephric chamber containing the glomus. The mesonephros began development at somite XVI. By 20 days post-fertilization, the anterior nephrostome began to

disappear and definite degeneration of the pronephros begins. The pronephros of sturgeon was considered more primitive and better developed than in other ganoids and *Polypterus* and the chambers were more completely fused than in any other vertebrate.

Fraser River White Sturgeon Working Group. 2005. Fraser River white sturgeon conservation plan. Draft for public review, July 2005. Report prepared for the Fraser River Sturgeon Conservation Society by Solander Ecological Research, Victoria, BC. x + 67 p.

This conservation plan provided a description of white sturgeon and discussed distribution, genetic diversity, biology, habitat, and values; threats and reasons for decline; goals and objectives, recommended actions; completed or partially completed actions; and benefits, conflicts, and challenges. The goal of the conservation plan was to "...ensure that naturally reproducing populations of white sturgeon flourish over the long-term throughout the species' natural distribution in the Fraser River basin, and opportunities for beneficial use of each of the major stock groups are provided, if and when feasible" (pg. 43). Although this document does not apply to lake sturgeon, it does provide an example of a conservation plan for sturgeon.

Friday, M. 2002. Lake Sturgeon Assessments 2001-2002 Update. Ontario Ministry of Natural Resources, Upper Great Lakes Management Unit - Lake Superior. 6 p. Available from <http://www.fws.gov/midwest/sturgeon/omnrfs-02assmts.htm> [accessed 3 April 2006].

Ontario Ministry of Natural Resources sturgeon assessments in the Black Sturgeon, Kaministiquia, Goulais and Pic rivers were described. Sixteen sturgeon were netted in the Black Sturgeon River. Biological data (length, weight, sex) was tabulated for nine of these. Updated results of a radiotelemetry study of lake sturgeon movements in the Kaministiquia River were provided. In the Goulais River biologists were gathering information on the physical characteristics of the lake sturgeon population. In the Pic River area, 16 lake sturgeon were sampled (13 from the Pic River, 3 from the Kagiagno River and 1 from the Black River) to collect tissue samples for genetic analysis.

Fuerst, P.A., Cavender, T.M., Porter, B., Krieger, J., and Maybruck, J. 2000. Preliminary results from genetic studies of population structure in the lake sturgeon of the Great Lakes, p. 11-12. *In* C. Lowie (ed.) Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization. Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **2000-01**. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 3 April 2006].

Gaikowski, M.P., Schleis, S.M., Weisser, J., and Gingerich, W.H. 2004. Improving electrofishing methods to sample juvenile lake sturgeon populations. *In* Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The purpose of this study was to determine the optimal stimulus for electrotaxis while minimizing peri-notochordal hemorrhage on age-0 lake sturgeon. Current type, voltage gradient, pulse frequency and duty cycle were examined in a laboratory test chamber. Promising parameter combinations were then tested outside in concrete ponds where capture rates varied from 50% to 89%. Initial findings indicated combinations of pulsed direct current of 0.3-0.5 V/cm, 60-80 Hz, and 10-25% duty cycle were the most efficient for capture while minimizing the injury to age-0 fish. This study was still ongoing.

Galarowicz, T. 2003. Conservation assessment for lake sturgeon (*Acipenser fulvescens*). USDA Forest Service, Eastern Region, Milwaukee, WI. 21 p. + app.

This document was a compilation of the background information necessary to complete a conservation strategy for lake sturgeon. The following topics were addressed: description of lake sturgeon, life history, ecology, dispersal/migration, habitat, distribution and abundance, range-wide status, population biology and viability, potential threats, summary of land ownership and existing habitat protection, summary of existing management activities, past and current conservation activities, and research and monitoring. A list of

contacts was provided at the end of the document.

Garceau, S., and Bilodeau, P. 2003. La dérive larvaire de l'esturgeon jaune (*Acipenser fulvescens*) à la rivière des Prairies, au printemps 2001. Société de la faune et des parcs du Québec, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Rapport technique **16-09**: x + 27 p. + apps.

The objective of this study was to determine whether abundance of lake sturgeon larvae from the des-Prairies River could be used to predict recruitment. The spawning site on the des-Prairies River was considered to be the most important for the lake sturgeon population in the St. Lawrence Seaway. Five stations were sampled between May 9 and June 20, 2001. A total of 1,572 larvae were captured. A bi-modal frequency was observed in the catch per unit effort over time, peaking on May 26 and 28. The absolute abundance in 2001 was estimated at 7.3 million, compared to 8.6 million in 1994, 1.9 million in 1995, 1.2 million in 1996, 6.5 million in 1997, 4.2 million in 1998, 2 million in 1999, and 4.3 million in 2000.

Garceau, S., and Bilodeau, P. 2004. La dérive larvaire de l'esturgeon jaune (*Acipenser fulvescens*) à la rivière des Prairies, aux printemps 2002 et 2003. Québec Ministère des Ressources naturelles, de la Faune et des Parcs, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Rapp. Tech. **16-21**: Pagination unknown.

This document was not available for annotating.

Gardiner, B.G. 1984. Sturgeon as living fossils, p. 148-152. *In* N. Eldridge and S. M. Stanley (ed.) Sturgeons as living fossils. Springer Verlag, New York.

The fossil history of extinct and present-day sturgeon was briefly reviewed. Characters separating the genera *Scaphirhynchus* and *Pseudoscaphirhynchus* were weak, and that the fundamental similarities were sufficient to group the 5 species of the two genera under a common genus. This work was referred to in the key to the acipenseriforms.

Garvey, M. 2001. A comparison of spawning lake sturgeon (*Acipenser fulvescens*) in Lac Deschênes and Lower Allumette. Ontario Ministry of Natural Resources, Southcentral Science and Information Section, Kemptville, Ontario. 12 p.

This study examined mature lake sturgeon using spawning shoals below the Chats Falls Generating Station on Lac Deschênes and in Lower Allumette, along the Ottawa River, to determine the reproductive success of these populations. Lac Deschênes was chosen because it represented a site that had been subject to human disturbance. The substrate types ranged from flat bedrock to small and medium broken rocks. Lower Allumette was chosen because it represented a relatively undisturbed habitat. Three sets of rapids drain into the Lower Allumette (Beckett's Rapids, Lost Channel Rapids, and Allumette Rapids) and all were evaluated for the presence of spawning sturgeon. Over 152 hours of fishing, 117 lake sturgeon were caught in the Lower Allumette (including one recapture). The mean total length was 86 cm and the mean weight was 3.77 kg. Only 8 sturgeon were caught in Lac Deschênes after 298.21 hours of fishing. The mean total length was 121 cm and the mean weight was 10.39 kg. Length and weight frequency distributions are presented. In both areas, few ripe sturgeon were caught, so the exact locations of spawning areas remain unknown. Increased sampling over the spawning shoal and the use of drift nets in the Lower Allumette were recommended to determine the success of spawning and larval lake sturgeon.

GDG Conseil inc. 2001a Réfection de la centrale de La Gabelle. Programme de surveillance et de suivi environnemental. Utilisation par les poissons d'un nouveau secteur de fraie aménagé en aval de la centrale de La Gabelle - printemps 2001. Rapport présenté à Hydro-Québec, vice-présidence Exploitation des équipements de production, Unité Hydraulique et Environnement, Montréal, Québec. vi + 29 p. + apps.

A study was done in 2001 to monitor the use of an artificial spawning ground created in 1999 and of an existing shoal by lake sturgeon and other fish species during low runoff conditions downstream from the La Gabelle dam. A prior study in the spring of 2000 demonstrated that lake sturgeon used the spawning grounds during

high flow conditions. Egg sampling was carried out using 7-9 driftnets and 8-9 artificial substrate stations between May 9 and 24 when the water temperature was 8°C. Gill nets (7.6 and 10.2 cm mesh size) were used to sample fish between May 9 and 14. Water temperature and current speed were measured every day at most driftnet sites. Back-calculation of spawning dates indicated that lake sturgeon spawned between May 13 and 19 when the water temperature was 12°C. No statistical differences were observed between the number of eggs collected on the existing shoal and on the artificial spawning ground, although values were lower in 2001 than in 2000. It was presumed that the reduced velocity on the shoal resulted in an increase in the surface area of the spawning ground and a decrease in egg densities. Lake sturgeon and longnose sucker utilized the new spawning grounds the most. The studies in 2000 and 2001 confirmed the use of the spawning ground by lake sturgeon, longnose sucker, white sucker, walleye, northern pike, mooneye, smallmouth bass, and rock bass. The results indicated that lake sturgeon used the shoal and artificial spawning site under a wide range of runoff conditions.

GDG Conseil inc. 2001b Réfection de la centrale de La Gabelle. Programme de surveillance et de suivi environnemental. Utilisation par l'esturgeon jaune d'un nouveau secteur de fraie aménagé en aval de la centrale de La Gabelle - printemps 2000. Report prepared for Hydro-Québec, Montréal, Québec. vi + 33 p. + apps.

Hydro-Québec increased the size of a shoal used by lake sturgeon for spawning downstream from the La Gabelle generating station in the summer of 1999. Rocks were deposited to increase the area by 1,300 m². Large blocks (1 to 3 m³) were placed in certain locations in order to slow the current for shelter areas. A study was done to quantify lake sturgeon spawning on the original and newly constructed spawning grounds. Sampling took place between May 17 and 29, 2000, using experimental gill nets and trays with artificial spawning substrate to collect eggs. Lake sturgeon eggs were collected on May 19 while the water temperature was 9.6°C. Spawning peaked between May 21 and 25 while the average water temperature was over 10°C and the water flow in the Sainte-Maurice river was under 1,400 m³/s. Results indicated that lake sturgeon made use of the new spawning

grounds with egg densities greater than ones in the area of the original shoal. A total of 131 lake sturgeon were captured with gill nets, tagged and released. Estimating the abundance of sexually mature fish was impossible due to their low instances of recapture. The catch per unit effort was five times higher in the spring of 2000 than in 1999 which was attributed to greater flow rates and the absence of floating logs.

Geddes, C., and Rutherford, E. 2005. Classification & visualization of lake sturgeon habitat suitability using the Great Lakes GIS. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 16 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 04 May 2006].

Gendron, M., Lafrance P., and Lahaye, M. 2002. Suivi de la frayère aménagée en aval de la centrale de Beauharnois - Printemps 2002. Report prepared by Environnement Illimité inc. for Hydro-Québec, Production Division, Montréal, Québec. iv + 38 p. + apps.

Walleye and lake sturgeon were monitored at an artificial spawning ground (3000 m²) downstream of generating station no.3 at the Beauharnois dam at Saint Louis Lake on the St. Lawrence Seaway, Québec. The spawning ground was created in 1998 and monitoring was carried out between 1999 and 2002. A removal of silt and vegetation on part of the grounds occurred in 2002 in order to assess use by and effect on development of walleye and lake sturgeon. Data show lake sturgeon never made use of the spawning ground while walleye spawned at the site only in 1999. Not long after the cleaning of the spawning grounds vegetation had already returned and a layer of silt was evident. Spawners were captured downstream of the generating station in all years of the study and were probably searching for suitable spawning grounds. It was suggested that effort be focused on other sites to enhance lake sturgeon spawning habitat.

Genoa National Fish Hatchery. 2003. Genoa National Fish Hatchery annual report 2002. United States Fish and Wildlife Service, Genoa, WI. 4 p.

This document was not available for annotating.

Genoa National Fish Hatchery. 2004. Genoa National Fish Hatchery annual report 2003. United States Fish and Wildlife Service, Genoa, WI. 7 p.

This document was not available for annotating.

Genoa National Fish Hatchery. 2005. Genoa National Fish Hatchery annual report 2004. United States Fish and Wildlife Service, Genoa, WI. 7 p.

This document was not available for annotating.

German, M.J. 1968. Biological survey of the Abitibi River, 1967. Ontario Water Resources Commission, Biology Branch. 13 p.

This document was not available for annotating.

Gibbons, D.W., Anderson, P.J., and Perham, R.N. 1970. Amino acid sequence homology in the active site of rabbit and sturgeon muscle aldolases. *FEBS Lett.* 10: 49-53.

The sturgeon muscle used in this study came from the Ottawa River. It was presumed to be lake sturgeon, but the species was not given in this paper. There was strong homology around the lysine residue in the aldolases from rabbit muscle, sturgeon muscle and rabbit liver. All of the enzymes were tetrameric with a subunit molecular weight of approximately 40,000. Work in progress on muscle aldolases from other sturgeon suggested there were sequence differences that may have been species specific.

Gibbons, I., Perham, R.N., and Anderson, P.J. 1972. Amino-acid sequence homology in the muscle aldolases from sturgeons of different species. *Nature New Biology* 238: 173-174.

This study was based on a comparison of the sequence homology around the active-site-lysine residue of aldolases from *Acipenser fulvescens*, *A. sturio*, *A. oxyrinchus*, and *A. transmontanus*. The peptide containing the active-site-lysine residue and an eighteen-residue peptide adjoining it in the primary structure were isolated from aldolases. In all four species, the peptides SXb1T3 had identical primary structure. Residues 29 and 31 were variable. In aldolases from *A. fulvescens* and *A. transmontanus* position 29 was occupied by tyrosine. In the aldolases of *A. sturio* and *A.*

oxyrhynchus the tyrosine was occupied by asparagine. Serine occurred in position 31 of the aldolase from *A. fulvescens* but alanine occupied this position in the other three species. The primary structure of muscle aldolase was identical from *A. sturio* and *A. oxyrhynchus*. Two replacements occurred between the aldolases of these species and *A. fulvescens*. *A. transmontanus* had an intermediate structure for its aldolase at position 31, but at position 29 it was identical to both *A. sturio* and *A. oxyrhynchus*. The authors acknowledged that their sturgeon sample size was small (one individual in most cases), and commented on the fact that this enzyme was highly conserved in such diverse animals as the pig, ox, and rabbit. They suggested that the European species of sturgeon were likely allopatric.

Gibson, D.W., Aubrey, S., and Armstrong, E.R. 1984. Age, growth and management of lake sturgeon (*Acipenser fulvescens*) from a section of the Abitibi River. Ontario Ministry of Natural Resources, Cochrane District. 33 p. [Unpublished].

This document was not available for annotating.

Gillette, B., and Diana, J. 1997. Movements of lake sturgeon in the St. Clair River, Michigan, p. 453. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Gillis, T.E., and Ballantyne, J.S. 1996. The effects of starvation on plasma free amino acid and glucose concentrations in lake sturgeon. *J. Fish Biol.* **49**: 1306-1316.

This study examined the effects of starvation on the metabolism of lake sturgeon. Haematocrit, plasma glucose concentrations, and plasma free amino acids were measured. Haematocrit decreased with starvation, suggesting a decreased oxygen carrying capacity of the blood. Plasma glucose levels decreased in the starved group only at day 10 of the experiment. There were no differences between groups of alanine, aspartate, and serine. Increased levels were observed for glutamine throughout the experiment. After 45 days of starvation, increases in concentrations of arginine, tyrosine, valine, methionine, tryptophan, phenylalanine, glutamate, glycine, isoleucine, histidine, and

leucine were observed. These results, in combination with the maintenance of blood glucose concentrations, indicated active gluconeogenic processes in the liver supported by muscle proteolysis.

Glover, C.R. 1961. The sturgeon in Pennsylvania. *Penn. Angler Jan.*: 3.

This popular article introduced the reader to the acipenserids of North America and recounted the history of commercial exploitation of lake sturgeon. This was accompanied by a description of the life history and a comparison with other sturgeon. Photographs accompanied the text.

Goddard, J. 1963. The lake sturgeon (*Acipenser fulvescens*) of Chipman Lake, in the Geraldton Forest District of Ontario. Ontario Department of Lands and Forests MS. Rep. 23 p.

The first commercial license to fish for lake sturgeon was issued for Lake Chipman in 1962. A total of 250 sturgeon were caught, 16 of which were tagged and released. Two hundred and thirty-four were killed for the market, giving a total harvest of 5,400 pounds. To gather baseline data for future management strategies, the harvested fish were aged, measured for lengths and weights, sexed, and the gonads examined for maturity. The mean coefficient of condition [K(FL)] was calculated to be 2.73 (from 204 individuals). Lake sturgeon of Lake Chipman were less fat and robust than those of Lake St. Francis. The sturgeon ranged in age from 25-92 years with the majority between 35 and 50 years. The mean annual increment was 0.5 pounds between 25-35 years, 0.6 pounds between 35-45 years, and 1.5 pounds between 45-64 years. Sturgeon reached legal commercial size at a length of approximately 43.5 inches and a total weight of 17 pounds. Of 226 sturgeon sexed, 147 were female and 72 male. Based on analyses of annuli from pectoral fin ray sections, the spawning pattern showed notable variation. All sturgeon that were marketed had spawned at least once. The mean depth of capture was 14.8 feet. An average of 37.5% of the total weight of the sturgeon was lost in dressing. During fall and winter, 16.3% of the body weight of females may have consisted of near mature roe. It was calculated that approximately 2/3 of the lake bottom was suitable substrate for sturgeon. Assuming an

optimistic annual quota of 2,150 pounds of whole sturgeon, it was deduced that little if any profit would come out of a long term commercial venture.

Goforth, R.R. 2000. Special animal abstract for *Acipenser fulvescens* (lake sturgeon). Michigan Natural Features Inventory, Lansing, MI. 4 p. [Brochure]. Available from http://web4.msue.msu.edu/mnfi/abstracts/aquatics/Acipenser_fulvescens.pdf [accessed 3 April 2006].

The state status and global and state rank of lake sturgeon are given. Their total range, state distribution and best survey time are summarized. Habitat, biology, conservation/management and research needs were also discussed.

Golder Associates Ltd. 2002. Fisheries, p. 131-155. In Meridian Dam preliminary feasibility study. Submitted to Alberta Environment, Edmonton, AB and Saskatchewan Water Corporation, Moose Jaw, SK. Publication No. **T/642**. Available from www3.gov.ab.ca/env/ [accessed 3 April 2006].

The results of an instream habitat assessment and fish community sampling in the South Saskatchewan River between the Grand Forks and the Red Deer River confluence and on the lower Red Deer River were discussed. A total of 23 fish species are known from the South Saskatchewan River. At writing, none were considered endangered or threatened, but lake sturgeon were listed as a special management species. A total of 12,288 fish were captured with lake sturgeon making up 0.7% of the catch. Seasonal movements were monitored by radiotelemetry and were discussed. Habitat use for each of the survey sites was summarized in Table 5.2-4 (pg. 139). Lake sturgeon were listed as a high priority management species as they have a high recreational importance and are targeted by most anglers. Potential impacts of the construction of the Meridian Dam were discussed in detail.

Golder Associates Ltd. 2004a. 2004 Groundhog River lake sturgeon survey, spring 2004. Prepared for Falconbridge Limited, Montcalm Mine Project. Pagination unknown.

This document was not available for annotating.

Golder Associates Ltd. 2004b. Report on Baseline Aquatic Study 2003 Summer/Fall Sampling Program Groundhog River, Timmins, Ontario. Montcalm Mining Project. Prepared for Falconbridge Limited, Montcalm Mine Project. viii + 52 p. + apps.

This report detailed the results of a baseline aquatic study on the Groundhog River. Topics included fish habitat mapping, fish health assessment (emerald shiner and mottled sculpin), the benthic invertebrate community, sediment sampling, and surface water quality. Several adult lake sturgeon were observed, usually over substrates of gravel/sand or cobbles. Six juvenile and one adult lake sturgeon were caught. Due to the small sample size habitat use could not be determined for lake sturgeon.

Goodyear, C.D., Edsall, T.A., Ormsby Dempsey, D.M., Moss, G.D., and Polanski, P.E. 1982a. Atlas of the spawning and nursery areas of Great Lakes fishes. Volume VI: St. Clair River. United States Fish and Wildlife Service, Washington, DC. FWS/OBS **82/52**: vi + 18 p.

A map detailing sturgeon spawning and nursery areas in the St. Clair River is shown on page 4. A brief discussion of sturgeon at specific locations follows. Spawning begins in the St. Clair River in mid-May, and channels of the river delta are important spawning areas.

Goodyear, C.D., Edsall, T.A., Ormsby Dempsey, D.M., Moss, G.D., and Polanski, P.E. 1982b. Atlas of the spawning and nursery areas of Great Lakes fishes. Volume III: St. Mary's River. United States Fish and Wildlife Service, Washington, DC. FWS/OBS **82/52**: vi + 22 p.

A brief description of lake sturgeon spawning areas on the St. Mary's River is given on page 4. Historic spawning grounds include the St. Mary's Rapids area, and the rock area between East Neebish and Sugar Islands.

Gough, J. 1991. Fresh Water, p. 47-52. In Fisheries Management in Canada 1880-1910. Can. Manuscr. Rep. Fish. Aquat. Sci. **2105**.

The fisheries reviewed include river systems, the Great Lakes, and the Prairie Provinces. The harvest of sturgeon in Manitoba was used as an example of the rapid destruction of a fishery. In

1895, 104,240 pounds were harvested, in 1900, 981,500 pounds were harvested, in 1905, 600,000 pounds were harvested, and by 1909 the harvest was reduced to 94,300 pounds.

Goyette, D., Gunette, S., Fournier, N., Leclerc, J., Roy, G., Fortin, R., and Dumont, P. 1988. Maturité sexuelle et périodicité de la reproduction chez la femelle de l'esturgeon jaune (*Acipenser fulvescens*) du fleuve Saint-Laurent. Qué. Minist. Loisir Chasse Pêche. Serv. Aménagement Exploit. Faune. Dir. Reg. Montr. Rapp. Trav. **06-02**: 84 p.

A sample of 800 lake sturgeon was examined from commercial operations. The Lac Saint-Louis females reached sexual maturity at an average age of 27 years and length of 133 cm. Female sturgeon in Lac Saint-Pierre spawned about every 9.4-9.7 years. Both age at maturity and spawning intervals were higher than reported before for this species. The oogenesis was estimated to last 5 years, culminating in spawning, followed by a four year recovery phase. The manner in which maturation cycles influenced the growth pattern of females was tested by the contingency periodogram applied to annual increment series drawn from Roussow's (1957) examples. It supported the qualitative estimate that dominant periods of growth cycles had an 8-9 year periodicity. Dominant growth periods for the two populations examined in the present study lasted 6, 8 or 11 years. No significant differences were found between male and female growth patterns during adolescence (4-15 years), although ages for sexual maturity differed. Automatic classification based on correlation analysis and discriminant analysis did not reveal a significant relationship between growth pattern during the last years of life and the state of sexual maturity at capture.

Graham, K. 1984a. Missouri's lake sturgeon reintroduction plan. Missouri Department of Conservation, Fish and Wildlife Research Center, Columbia, Missouri. 11 p.

Reasons given for the projected success of fingerling stocking in the Mississippi River versus the Missouri River included larger littoral areas and greater benthic production. It was suggested that the best place to release the sturgeon fingerlings was into sloughs and that rock dikes on either side of the river would serve as spawning sites. Several reservoirs were

suggested as possible sites for sturgeon stocking.

Graham, K. 1984b. Reintroduction of lake sturgeon in Missouri. Performance Report: Dingell-Johnson Project, F-1-R-35. Missouri Dept. Conserv., Study **S-35**: 7 p.

See Graham, 1986 (this bibliography) for the final report on this project.

Graham, K. 1984c. Reintroduction of lake sturgeon in Missouri. Missouri Department of Conservation, Columbia, Missouri. 11 p.

Historical information on lake sturgeon was discussed, including the decline of populations due to overfishing, sturgeon habitats and habits, and reproduction. Spawning was closely tied to water temperature and even a drop of only a few degrees could cause a temporary halt in spawning. To test stocking schemes fingerlings would be stocked into small bodies of water (2 to 10 acres) which could be sampled in 2-3 years. The Mississippi River was probably better for stocking due to its diverse benthic community and rock dikes, which were similar to riprap on the Wolf River that provided suitable spawning substrate. Recommendations were to stock in a productive reservoir with rivers in the vicinity that contained gravel and boulders suitable for spawning.

Graham, K. 1986. Reintroduction of lake sturgeon in Missouri. Final Report: Dingell-Johnson Project F-1-R-35. Missouri Dept. Conserv., Study **S-35**: 11 p.

This was a preliminary study to evaluate culturing and the reintroduction of fingerling lake sturgeon into Missouri. Eyed sturgeon eggs were obtained from Wisconsin and hatched at the Blind Pony Hatchery. After swimup the fry were fed *Daphnia* and live young brine shrimp. They were either stocked into fertilized ponds (0.5 and 1.5 acres) or reared in fiberglass troughs and fed artificial diets, live and frozen tubifex worms, live aquatic black worms and frozen adult brine shrimp. Ponds were filled and fertilized 10-14 days prior to stocking. Afterwards they were fertilized weekly with 150 lb/acre each of dehydrated alfalfa meal and dehydrated cow manure, 50 lb/acre of Brewer's yeast, and 25 lb/acre of fresh chicken manure throughout the growing season. This method of culture was largely unsuccessful as few

sturgeon were recovered. Best results were obtained by culturing sturgeon in tanks and troughs, starting on *Daphnia* and live brine shrimp, and after 1 inch in length switching to live aquatic worms, frozen bloodworms or frozen brine shrimp. Frozen adult brine shrimp were cheapest at \$3.00/lb. Survival in troughs was excellent, with fish reaching 4.0 inches after 45-50 days at 60-65°F, and disease was generally not a problem. Elevated ammonia levels of 0.275 ppm apparently killed young sturgeon.

Graham, K. 1992. A plan for recovery of lake sturgeon in Missouri. Missouri Department of Conservation, Jefferson City, Missouri. iii + 11 p.

This report outlined several goals and objectives for a plan to manage the recovery of lake sturgeon in the Mississippi and Missouri rivers. The goals were to: 1) establish a self-sustaining population of lake sturgeon in the Mississippi and Missouri rivers, comprised of 10 year classes, by 2001; 2) characterize and quantify lake sturgeon habitat in the Mississippi and Missouri rivers and its tributaries with recommendations to protect and improve it; 3) develop methods for assessing the status of lake sturgeon populations in the Mississippi and Missouri rivers by 2001; 4) involve the public to ensure their understanding, appreciation, and cooperation in the lake sturgeon recovery effort; and 5) to establish a lake sturgeon population capable of supporting a sport harvest. An implementation schedule was tabulated.

Graham, K., and Hamilton, J. 1997. Missouri's approach to lake sturgeon reintroduction, p. 449. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Great Lakes Science Center. 2000. Helping the ancient sturgeon. GLSC Fact Sheet 2000-4: 2 p.

This short fact sheet described the physical characteristics of lake sturgeon and their biology, including diet and life history. The history of the fishery and human uses were discussed. The Detroit River, Lake St. Clair and the St. Clair River system have the largest population of free-ranging, river spawning lake sturgeon in the Great Lakes. Management efforts were briefly examined.

Greil, R., Donovan, M., and Sutton, T. 2002. Assessment of lake sturgeon in the St. Marys River 2002. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 19 p.

This document was not available for annotating.

Guay, G., and Gendron, M. 2004. Suivi de l'utilisation du bassin de Pointe-des-Cascades par l'esturgeon jaune et les autres espèces - 2004. Rapport d'Environnement Illimité inc. pour Hydro-Québec, Production Barrages et environnement, unité Environnement, Montréal, Québec. viii + 43 p. + apps.

The wildlife and parks society of Québec (FAPAQ) had requested that Hydro-Québec increase water levels in the Pointe-des-Cascades reservoir near mid-June in order to increase habitat for fish. The objectives of this study were to characterize migration and reproduction of lake sturgeon and movements of other fish species. Observing spawners and collecting eggs in rapids using artificial substrates were the principle sampling methods for lake sturgeon. Electrofishing, gill netting, trapnets and seining were used to monitor movements of other fish species. Sampling during the sturgeon migration and spawning season took place from mid-May to mid-June, while sampling for other fish species took place at the end of April, beginning of May, end of May, beginning of June and in mid-July. Lake sturgeon monitoring showed that the first arrivals in the Pointe-des-Cascades reservoir were on May 28 when the water temperature was 14.5°C. Lake sturgeon concentrations were observed at the foot of the Pointe-du-Buisson dam up until June 16 while the water temperature was 20°C. No lake sturgeon spawning was observed and no eggs were collected on the artificial spawning substrate. While water temperature was high, spawning may have still occurred as it is known that lake sturgeon will spawn in temperatures up to 21.5°C. Sampling may be undertaken upstream from the Pointe-du-Buisson dam to confirm the use of the Pointe-des-Cascades reservoir for spawning. Before increased water levels in the Pointe-des-Cascades reservoir, 3,652 fish comprising 21 species were captured using all types of sampling methods. After higher water levels, 6,820 fish comprising 29 species were collected. Many fish were young of the year, which confirmed the use of Pointe-des-

Cascades reservoir as important spawning, rearing and feeding area.

Guderley, H., Hamel, L., and LaFond, J. 1983. Close resemblance between muscle pyruvate kinase from a primitive vertebrate, the river sturgeon *Acipenser fulvescens*, and the ancestral type K isozyme. *J. Comp. Physiol.* **153**: 247-256.

Pyruvate kinase (PK) was present in lake sturgeon in the form of two tissue specific isozymes. One was present in muscle, heart and spleen, and one in eyes, liver, gills, and intestine. Sturgeon muscle PK showed partial immunological cross-reactivity to dog and frog muscle PK. Phosphoenolpyruvate saturation curves for sturgeon muscle pyruvate were expressed by the equation $S_{0.5} = 0.33 \text{ mM}$ and the Hill coefficient, n_H , was 1.24. The enzyme was strongly inhibited by phenylalanine, alanine and MgATP but inhibition was reversed by fructose 1, 6 biphosphate. The kinetic properties of sturgeon PK closely resembled those of vertebrate type K PK but not the type M isozymes of higher vertebrates. It was extrapolated that the sturgeon muscle PK would be a slightly modified transcript of the basic type K gene, while the higher type M isozyme represented highly modified transcripts.

Gudger, E.W. 1928. Association between sessile colonial hydroids and fishes. *Ann. Mag. Nat. Hist.* **1**: 17-48.

Ten cases were cited of relationships between fishes and coelenterates, ranging from symbiosis in South African fishes to parasitism by *Polypodium* of the eggs of the Volga starlet. Eight hydroids were listed in association with 10 fishes, with one hydroid parasitizing three different fishes.

Guenette, S., and Fortin, R. 1991. Comparaison des phenotypes morphologiques des esturgeons jaunes (*Acipenser fulvescens*) du couloir fluvial du Saint-Laurent et du Lac des Deux Montagnes, dans le sud du Québec, p. 327-328. In P. Williot (ed.) *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989. Bordeaux, France. [Abstract only].

A total of 41 morphometric characters and 2

meristic characters were compared between the two populations. There was a difference of 1.5 branchiospines between Lake Saint-Louis sturgeon and those from Lake Saint-Pierre and Lac des Deux Montagnes, but the range was identical in all groups. Lac des Deux Montagnes fish had a proportionally higher and longer head than sturgeon from elsewhere. There were significant morphometric differences between Nicolet, Sorel-Berthier islands, Gentilly and Lac Saint-Louis sturgeon. Differences were very small when each descriptor was considered separately.

Guenette, S., Fortin, R., and Rassart, E. 1993. Mitochondrial DNA variation in lake sturgeon (*Acipenser fulvescens*) from the St. Lawrence River and James Bay drainage basins in Québec, Canada. *Can. J. Fish. Aquat. Sci.* **50**: 659-664.

Sympatric lake sturgeon from the St. Lawrence River drainage basin (St. Lawrence and Ottawa rivers and Lac des Deux Montagnes) and from the Waswanipi River were assessed for genetic differentiation. Genetic divergence was relatively low with only three genotypes found ($d=0.219-0.744\%$). Genotype 1 was present at all of the sites and genotype 2 was present in Lac des Deux Montagnes, the Ottawa River, and the Waswanipi River. This suggested that fish from the St. Lawrence and Ottawa rivers and Lac des Deux Montagnes did not circulate between all of the water bodies studied. The sturgeon from the St. Lawrence River formed a homogenous genotypic group that was not found to be significantly different from Lac des Deux Montagnes. Populations disturbed by anthropogenic effects, such as the James Bay drainage basin population, appeared to have greater genetic heterogeneity. Because there were significant morphological differences with low genetic divergence, it appeared that genotype and phenotype were not linked in this case.

Guenette, S., Goyette, D., Fortin, R., Leclerc, J., Fournier, N., Roy, G., and Dumont, P. 1992. La périodicité de la croissance chez la femelle de l'esturgeon jaune (*Acipenser fulvescens*) du fleuve Saint-Laurent est-elle reliée à périodicité de la reproduction? *Can. J. Fish. Aquat. Sci.* **49**: 1336-1342.

One hundred and twenty five female lake sturgeon, 24 years or older, were collected from

the St. Lawrence River. Annual increments of the first ray of the pectoral fin were measured to test the relationship between growth patterns at the margins of the sections and the state of maturity of the fish. Twenty one of the females equal to or greater than 34 years old were treated as a temporal series and analyzed with a contingency periodogram. The mean age at first spawning was determined using the age at the end of the first belt of crowded annuli. Only 3 of the 21 fish over 34 exhibited a typical succession of belts of large and narrow rings, with 5 to 11 years being the most frequent periods. The mean age of first spawning was 19 years using the contingency periodogram, and 26 years by examining the gonads.

Guenette, S., Rassart, E., and Fortin, E. 1992. Morphological differentiation of lake sturgeon (*Acipenser fulvescens*) from the St. Lawrence River and Lac des Deux Montagnes (Québec, Canada). *Can. J. Fish. Aquat. Sci.* **49**: 1959-1965.

Forty-one morphometric characters and two meristic traits were used on 200 lake sturgeon from 5 sites along the St. Lawrence River (Lacs Saint Pierre and Saint-Louis and the river downstream from Lake Saint Pierre) and Lac des Deux Montagnes. Although the range was identical in all groups, the study revealed a difference of 1.5 gill rakers between sturgeon from Lac Saint-Louis and sturgeon from Lac Saint-Pierre and Lac des Deux Montagnes. Principal component and discriminant analyses illustrated that fish from Lac des Deux Montagnes had a significantly higher and longer head than those found in the St. Lawrence River (4 to 16 mm difference). Multivariate analysis revealed slight morphometric differences amongst fish in different parts of the St. Lawrence River.

Guilbart, F. 2002. Comparaisons du régime alimentaire et de la morphologie du système digestif de l'esturgeon jaune (*Acipenser fulvescens*) et de l'esturgeon noir (*Acipenser oxyrinchus*). Mémoire de maîtrise biologie, Université du Québec à Montréal, Montréal, Québec. Pagination unknown.

This document was not available for annotating.

Guilday, J.E. 1971. Biological and archaeological analysis of bones from a 17th century Indian village (46 PU 31), Putnam

County, West Virginia. W. VA. Geol. Econ. Surv. Rep. Archaeol. Invest. **4**: vii + 64 p.

This report discussed archaeological finds at the site of Buffalo Village (AD 1650) on the flood plain of the Ohio River (Putnam County, West Virginia). It was occupied by aboriginal farming and hunting people until contact with European settlers. A faunal list contained the names of the mammals, birds, reptiles and amphibians identified from analysis of bones. Lake sturgeon remains did not figure prominently, only one item was found and it corresponded to an estimated 50 pounds of meat. Remains of *Aplodinotus grunniens* (freshwater drum) were found to be the most common.

Gunderman, B.J. 2001. Population dynamics of lake sturgeon (*Acipenser fulvescens* Rafinesque) in the Manistee River. M.Sc. Thesis, Central Michigan University, Mount Pleasant, MI. 31 p.

This document was not available for annotating.

Gunderman, B., and Elliott, R. 2004. Assessment of remnant lake sturgeon populations in the Green Bay basin, 2002-2003. Report to the Great Lakes Fishery Trust. Project Number **2001.113**: viii + 97 p. Available from http://www.fws.gov/midwest/sturgeon/document_s/FinalReport-Elliottetal2004.pdf [accessed 3 April 2006].

The objectives of this study were to estimate the abundance of adult lake sturgeon during the spawning run in four Green Bay tributaries (Fox, Menominee, Peshtigo and Oconto Rivers); determine reproductive success; examine spawning habitat availability and use; determine the distribution and contribution of discrete spawning stocks to the mixed lake sturgeon population of Green Bay; and to estimate the overall Green Bay lake sturgeon population size. Over 450 lake sturgeon were captured between 1997 and 2003. The estimated run size ranged from 25 in the Oconto River, to more than 200 in the Peshtigo and Menominee rivers. Larvae were found in all four rivers, but abundance varied. Available spawning habitat ranged from 6-7 ha in the Fox and Peshtigo rivers, to more than 18 ha in the Oconto and Menominee rivers. The lower Green Bay lake sturgeon population consisted of mainly young lake sturgeon (less than 15 years) and a preliminary population estimate of 2,000 (at least 112 cm in length) is

given. Further field work was recommended so an effective rehabilitation strategy could be devised.

Gunderman, B., and Peterson, D. 2000. Abundance and age structure of adult lake sturgeon in the Manistee River. In 130th AFS Annual Meeting, St. Louis, MO. 20-24 August, 2000. Reflections. Pagination unknown. [Abstract only].

Gunderman, B., Elliott, R., Meronek, T., Lychwick, T., Kornely, G., Scribner, K., DeHaan, P., Lange, R., and Sutton, T. 2004. Status assessment of lake sturgeon stocks in the Lower Green Bay basin. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

From 1997 to 2003, over 450 sturgeon were sampled. Spawning populations were genetically discrete. Run size estimates varied from 25 individuals in the Oconto River, to more than 200 individuals in the Peshtigo and Menominee rivers. Relative abundance of larvae varied between tributaries. Spawning habitat varied from 6-7 hectares in the Fox and Peshtigo rivers, to greater than 18 ha in the Oconto and Menominee rivers. The mixed population in Green Bay was dominated by younger individuals (<15 years) with a population estimate of 2,000 sturgeon (>111.8 cm total length).

Gunn, D. 1875. Supplement No. 5 to the annual report being Appendices of the Fisheries Branch of the Canada, Department of Marine and Fisheries. Sessional Paper No. 5: Pagination unknown.

Gunn identified two species of sturgeon in Manitoba, *Acipenser rupestrinus* and *Acipenser rubicundus*. He captured individuals as large as six feet in length and 130 pounds in weight. As a result of overfishing or neglect, the author believed that one sturgeon did not enter the Red River for every one hundred that came yearly forty years prior [1835].

Gunther, A. 1870. Family I. Acipenseridae, p. 332-345. In Catalogue of fishes in the British Museum, VIII. London.

This concluding volume of the catalogue series listed *Acipenser liopeltis* as a new species (p.

334). *A. maculosus* and *A. rubicundus* were also mentioned. Kirsch and Fordice (1889) (see in this bibliography) synonymized them with the lake sturgeon, *A. rubicundus*.

Gusev, A.V., Dubinina, M.N., Pugachev, O.N., Raikova, E.V., Khotenovekij, I.A., and Ergens, R. 1985. A guide to the parasites of freshwater fish of the USSR, Vol. 2. Parasitic Metazoa (Part 1). Opredeliteli Faune SSSR No. 143: 418 p.

This document was not available for annotating.

Haas, B., and Thomas, M. 1997. Use of set-lines for sampling lake sturgeon in the St. Clair River, Michigan, p. 454. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Hannibal-Paci, C. 1997. *Namew* as an under-rated economic resource: a review for lake sturgeon (*Acipenser fulvescens*) in Manitoba's archaeological literature. Manitoba Archaeological Journal 7: 77-95.

This document provided a review of lake sturgeon in Manitoba's archaeological record. It noted that this information is often ignored by biologists and not sought after by archaeologists.

Hannibal-Paci, C. 1998. A case study of Ojibwe knowledge of lake sturgeon at Sagkeeng and the possibilities for co-management. Prepared for Sagkeeng First Nation, Fort Alexander, MB and Dr. Terry Dick, University of Manitoba, Winnipeg, MB. 46 p.

Traditional ecological knowledge, collected through interviews with Sagkeeng community members, was presented and discussed. These interviews took place as part of a larger study entitled "Cree, Ojibwe [Ojibwa, Ojibway] and scientific knowledge of lake sturgeon in the Hudson Bay Province and the possibilities for co-management".

Hannibal-Paci, C.J. 2000. "His knowledge and my knowledge": Cree and Ojibwe traditional ecological knowledge and sturgeon co-management in Manitoba. Ph.D. Thesis, University of Manitoba, Winnipeg, MB. ix + 278 p. + apps.

This thesis examined the application of Cree and Ojibwe [Ojibwa, Ojibway] traditional ecological knowledge to co-management of the Manitoba lake sturgeon fishery. Chapters included: Lake Sturgeon in Manitoba; A Theory for Traditional Environmental Knowledge and Co-Management; Lake Sturgeon Management in Manitoba; Case Study of Cree and Ojibwe Sturgeon Knowledge; The Nelson River Sturgeon Co-Management Board; and The Future for Lake Sturgeon in Manitoba. The author concluded that there were several issues that had to be resolved before co-management could be effective in Manitoba.

Hansen, M.J. (ed.) 1990. Lake sturgeon, p. 43-45. *In* Lake Superior: the state of the lake in 1989. Gr. Lakes Fish. Comm. Spec. Pub. **90-3**. Available from www.glfc.org/pubs/SpecialPubs/Sp90_3.pdf [accessed 3 April 2006].

This report described the existing fish community of Lake Superior and discussed the fishery objectives, one of which was to re-establish depleted stocks of native species such as lake sturgeon. In reviewing the progress towards fulfilling this objective, it was concluded that lake sturgeon stocks remained as suppressed localized populations under the control of local management agencies. Historically, over-harvest and habitat degradation have led to the depletion of stocks. Spawning populations of lake sturgeon occurred in the Bad, Sturgeon, Kaministiquia, Michipicoten, and Black Sturgeon rivers, all tributaries of Lake Superior. Spawning sturgeon were also reported off the harbor breakwall at Ashland, Wisconsin. Six agencies managed commercial and sport fishing regulations for lake sturgeon. The Departments of Natural Resources of Michigan, Wisconsin, and Minnesota prohibited possession by commercial fishermen. Strategies outlined to restore sturgeon populations included stocking of rivers with sturgeon juveniles reared in hatcheries, preventing habitat loss, and enforcing stringent water pollution laws.

Harkness, W.J.K. 1923. The rate of growth and the food of lake sturgeon (*Acipenser rubicundus* Le Sueur). Publ. Ont. Fish. Res. Lab. **18**: 15-42 (Univ. Toronto Stud. Biol. Ser. 24).

This report described the growth and food habits of lake sturgeon from Lake Nipigon, Ontario.

Otoliths were used to age sturgeon and were found to be adequate. The average age was 50 years. Sexual maturity was reached by 22 years of age. It was recommended that sturgeon up to the age of 35 years (50 inches in length and 27 pounds in weight) not be harvested. Chironomidae larvae, Mollusca, and Ephemerida nymphs were the main food items of sturgeon. Trichoptera larvae were numerous in the diet when Ephemerida were scarce or lacking. Sturgeon took any food of value, as long as it was abundant and easily acquired. Sturgeon did not appear to feed on fish eggs or fry. Although whitefish and lake sturgeon fed on similar organisms, the author did not think there was much competition as whitefish were found in deep water, while sturgeon frequented shallow water.

Harkness, W.J.K. 1980. Report on the sturgeon situation in Manitoba. Manit. Dept. Nat. Res. MS. Rep. **80-3**: iv + 18 p.

This report discussed the trends in the sturgeon fishery in Manitoba from 1876 to 1935. The harvest in meat ranged from a low of 600 pounds with a value of \$3,000 in 1876, to a high of 981,000 lbs with a value of \$58,890 in 1900. Caviar reached a peak harvest of 37,000 lbs in 1906. In 1901 there was evidence that the fishery was in trouble and production in Manitoba started to decline. Lac du Bonnet was opened in 1910 and 173,000 lbs were harvested. There was a brief discussion of lake sturgeon habits, including spawning locations. Sturgeon were rarely found in water deeper than 20 feet and tended to concentrate in the shallower areas of the lake. If there had been a more structured fishery with a continuous but reduced catch/year over the same period, more sturgeon might have been harvested with less damage to the fishery. It was recommended that any sturgeon fishery started in Manitoba harvest no more than 10,000 lbs annually, and that sturgeon not be taken between May 1 and July 1--perhaps as late as July 10 in the north. There were also concerns about protecting spawning and feeding grounds, the potential impacts of dams, and protection of sturgeon during spawning.

Harkness, W.J.K., and Dymond, J.R. 1961. The lake sturgeon, the history of its fishery and problems of conservation. Ont. Dept. For. Fish Wildl. Br. 121 p.

This is perhaps the most widely cited reference in the literature on lake sturgeon, and a valuable compendium of early knowledge of this fish. Its review of the literature drew on 116 references for information. Every aspect of the sturgeon studied prior to 1961 was covered, beginning with a description of juvenile and adult morphologies. On pages 8 and 9 were records of lake sturgeon weighing 129 pounds and 310 pounds, with a 7'11" sturgeon being the largest recorded. The two 'morphs' of lake sturgeon as reported by Roussow and Greeley were discussed. The food habits were discussed at some length and mayfly and chironomid larvae, molluscs (sphaerid clams), and crustaceans were said to be common in the diet. Their reputation as a voracious feeder on fish eggs was regarded as prejudiced. The efforts to feed young sturgeon (with no success) were described and the food of young sturgeon was considered a mystery. Lake sturgeon growth and reproduction were also discussed. The dates of spawning at various locations were listed (early May to as late as mid-June). Spawning temperature, sites and behavior were also discussed. Photographs of early development remained the earliest of their kind and early efforts at artificial propagation were described. The importance of the sturgeon to the native cultures was vividly portrayed, as was the exploitation that decimated the sturgeon populations. This sad account was replete with anecdotal information, unpublished eye-witness reports, excerpts from old reports (some as old as 1703) and quotes from past literature. Slow growth to commercial size, infrequent spawning, and habitat degradation were said to be the main causes for the decline of sturgeon. Conservation measures were discussed. The history of fishery regulations affecting sturgeon were critically analyzed.

Harlan, J.R., and Speaker, E.B. 1969. Sturgeon family, *Acipenseridae*, p. 34-36. In Iowa Fish and Fishing (4th edition). Iowa Conservation Commission.

The shovelnose and lake sturgeon were described in terms of their distribution in Iowa, their life history, food habits, and angling.

Harned, C.N., and Hackney, P.A. 1981. Occurrence of lake sturgeon, *Acipenser fulvescens*, in the Cumberland River of Tennessee. *J. Tenn. Acad. Sci.* 56: 59-60.

The authors reported the capture of two specimens below the Cordell Hull Dam on the Old Hickory Reservoir in Tennessee. One apparently healthy individual taken on 24 May, 1977, immediately below the dam, was 145 cm long and weighed about 23 kg. The second, captured in April 1978, had an estimated total length of 2 m and weighed 50 kg. The origin of these sturgeon remained unknown, although they may have been trapped in the reservoir when the dam was constructed.

Harris, R. 1952. The sturgeon harvest. *Wis. Conserv. Bull.* 17: 3-6.

In this article, caution was urged on the commercial harvest of lake sturgeon in view of its slow growth and late maturity. The lake sturgeon, its life history and distribution were briefly described. The article focused on the rationale for a winter spear fishing season on lakes Butte des Morts, Winneconne, and Poygan, and on the existing spear fishery on Lake Winnebago. In view of a suspected surplus, a special 15 day season was opened on lakes Butte des Morts, Winneconne and Poygan during February of 1952. The novelty drew considerable popular response. Spear fishermen cooperated by providing fisheries biologists with samples of gonads and fin rays. A total of 200 sturgeon were removed. The validity of this fishery was strongly advocated by the argument that 200 fish from 156,000 acres of water could hardly harm the fishery. The sport was promoted and specifications were provided at the end of the article on pre-requisites for this kind of adventure.

Hart, M.L. 1987. Considerations for the management of lake sturgeon (*Acipenser fulvescens*) commercial fisheries in Ontario, p. 85-90. In C. H. Olver (ed.) *Proceedings of a Workshop on the Lake Sturgeon (Acipenser fulvescens)*. Ont. Fish. Tech. Rep. Ser. 23.

This was a review of the problems and concerns of fishery managers as they related to lake sturgeon with some recommendations on ways to improve management. The declines of lake sturgeon populations were thought to be due to overfishing, increased market demands for the fish, habitat destruction, toxic effluents, increased angling pressure, and overfishing in subsistence fisheries. Management strategies should include sustaining annual yields, protection of broodstock, restoration of depleted

stocks, protecting and enhancing spawning and nursery habitat, and partitioning the harvest between commercial and sport fisheries. Smaller fish should comprise a substantial component of the quota and a slot limit should be considered. While information on age at maturity and length-at-age was important, this data was rarely available. Management of lake sturgeon on a watershed basis was recommended, since biological data differed substantially among regions. The proposed revision to the Ontario Fishery Regulations would allow the manager, through a condition of licensing, to specify species and size to be taken.

Hartman, W.L. 1973. Effects of exploitation, environmental changes, and new species on the fish habitats and resources of Lake Erie. Gr. Lakes Fish. Comm. Tech. Rep. 22: 43 p. Available from www.glfc.org/pubs/TechReports/Tr22.pdf [accessed 3 April 2006].

The changes of fish habitat in Lake Erie over the past 150 years were discussed. The greatest stresses on the watershed appeared to be the intensive commercial fishery, erosion, siltation, dam construction, nutrient loading, reductions in dissolved oxygen, and competition and predation caused by invading species. Causes of decline in lake sturgeon populations were examined.

Haugen, G.H. 1969. Life history, habitat and distribution of the lake sturgeon, *Acipenser fulvescens*, in the South Saskatchewan River, Alberta. Alberta Fish Wildl. Div. Res. Rep. 4: 27 p.

This study reported the life history characteristics of the lake sturgeon in the Alberta portion of the South Saskatchewan River. Age was determined for 223 lake sturgeon, aged 2 (208 mm long) to 51 years (1705 mm long). The mean growth increment varied from 263 mm for the 2-3 year age group to 13 mm for the 21-51 year age group. The male to female sex ratio was 1:1. Only 3 of the 97 females had mature eggs in their ovaries. The length - weight relationship was given by the equation $\text{Log}W = -9.067 + 3.286 \text{ Log}L$, where W is weight in kilograms and L is total length in millimetres. Of the food contents in the stomachs (prevalence in brackets), chironomids and tipulids (85.5%), ephemeropteran nymphs (75.4%), plecopteran nymphs (42.3%), odonate

nymphs (33%) and trichopteran larvae (73.2%) were important constituents. Fish occurred in 25% of the stomachs. An attempt was made to correlate fishing success to physical parameters. Depth and velocity of water flow were most important. All lake sturgeon were captured in waters over two meters deep with a flow rate less than 80 cm/sec.

Haugen, G.N. 1970a. Life history, habitat and distribution of the lake sturgeon, *Acipenser fulvescens*, in the South Saskatchewan River, Alberta. In Proceedings of the 18th Annual Workshop of the Great Plains Fisheries Workers Association. Pagination unknown. [Abstract only].

Haugen, G.N. 1970b. The preference of river minnows (Cyprinidae) and smelt (Osmeridae) in the diet of lake sturgeon (*Acipenser fulvescens*). Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. 10 p.

The efficacy of river minnows and smelt as sturgeon bait was tested. Set lines were baited with equal numbers of minnows and smelt in six sections of the South Saskatchewan River for a total of 504 hours. A total of 45 sturgeon were taken, of which 93% were by minnow baits. Catch per unit effort for minnows was 0.083 compared to 0.0059 for smelt. Of the captured fish, 82% came from Area 1. This area was characterized as having a 20-40% sand-silt bottom, lower water velocity and greater mean depth. All sturgeon were captured where water depths exceeded two meters. The angling success for lake sturgeon in the South Saskatchewan River was less than standard for a sport fishery. This report also exists under the title "The preference of river minnows (Cyprinidae) or smelt (Osmeridae) as bait for lake sturgeon (*Acipenser fulvescens*)".

Haxton, T. 2002. An assessment of lake sturgeon (*Acipenser fulvescens*) in various reaches of the Ottawa River. J. Appl. Ichthyol. 18: 449-454.

Relative abundance studies were initiated in nine reaches of the Ottawa River to assess the lake sturgeon population status using the fall walleye index netting (FWIN) and the near shore community index netting (NSCIN). A total of 28 lake sturgeon were captured by FWIN and 360 by NSCIN. The relative abundance, mean total length, and mean weight of lake sturgeon

differed among the nine reaches. Lake sturgeon were more abundant in natural than impounded reaches. No lake sturgeon were sampled in three of the reaches, two of which were subject to winter drawdown. Stresses caused by poor water quality, commercial harvest, and waterpower management may still be the main influences on lake sturgeon, but further assessment was required.

Haxton, T. 2003. Movement of lake sturgeon, *Acipenser fulvescens*, in a natural reach of the Ottawa River. *Can. Field-Nat.* **117**: 541-545.

Four lake sturgeon were captured in trapnets in Allumette Lake in late October of 1998. Mean total length was 89.2 cm. Radio transmitters were surgically implanted and tracking was conducted over a period of 2.5 years using a boat and an airpalne. Airplane tracking was the most effective and became the primary method used. Lake sturgeon displayed high fidelity to the basin in which they were sampled. The substrate in this area consists primarily of sand and clay, and therefore, should be productive for benthic invertebrates, which are the main prey of sturgeon. Juvenile sturgeon will remain in areas with moderate amounts of prey. The average distance moved was 2.5 km and the maximum was 10.6 km between trackings. The average home range for the four lake sturgeon was 1,528 ha. The sturgeon were generally found in shallow water with a mean depth of 3.5 m, and were occasionally found in water up to 12 m deep. The actual mean depth used may be greater than 3.5 m, since radio transmitter function decreased with increasing depth.

Haxton, T. 2005a. Spatial application of a habitat suitability index model for lake sturgeon. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 18 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 3 April 2006].

Haxton, T. 2005b. Steps toward the development of a management plan for lake sturgeon in the Lake St. Francis portion of the St. Lawrence River. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 11 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document>

[s/GLCoordMtg04/oralabstracts.htm](http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm) [accessed 3 April 2006].

Haxton, T.J. 2006. Characteristics of a lake sturgeon spawning population sampled a half century apart. *J. Gt. Lakes Res.* **32**: 124-130.

This study re-assessed the spawning population of lake sturgeon at Chats Generating Station (G.S.) on the Ottawa River. This population was initially assessed by Dubreuil and Cuerrier (1950, see in this bibliography) in the late 1940s. The objectives of the present study were to determine whether lake sturgeon still congregate below Chats G.S. during the spawning period, and to examine changes in the characteristics of the spawning population since 1949. Sampling was conducted from May 22 to June 13, 2001, May 26 to June 12, 2003, and May 25 to June 14, 2004 using monofilament gillnets. Eight lake sturgeon were captured in 2001, 58 in 2003 including 7 recaptures, and 17 in 2004 including 3 recaptures. In 2003, the spawning population was estimated at 202, and only males were found in spawning condition. Mean total length was 121.1 ± 18.2 cm in 2001, 117.6 ± 12.8 cm in 2003, 117.8 ± 11.2 cm in 2004, and 118.0 ± 13.3 cm for all years combined. In 1949, mean total length was found to be 101.7 ± 11.5 cm. The frequency of lake sturgeon < 110 cm in 1949 was 80.6% compared to 31.1% in the current study. Weight-length relationships were similar between studies, and growth rates were significantly slower for lake sturgeon in the current study. Ages ranged from 13 to 46 years in the current study and from 15 to 62 years in 1949, although ages in the current study had not been validated at the time of writing. The main change in the lake sturgeon population was that fewer small fish were sampled in the present study, indicating limited recruitment.

Hay-Chmielewski, E.M. 1987. Habitat preferences and movement patterns of the lake sturgeon (*Acipenser fulvescens*) in Black Lake, Michigan. *Mich. Dept. Nat. Res. Fish. Div. Fish. Res. Rep.* **1949**: 39 p.

Daily tracking of lake sturgeon was carried out using biotelemetry in Black Lake, Michigan, during the summers of 1985 and 1986 and for two weeks in October 1986 and January 1987. Preferred depths were 10.3 ± 2.14 m in summer and 7.1 ± 0.76 m in winter. Preferred prey included crayfish and mayfly larvae, which were correlated with preferred substrates. Lake

sturgeon neither schooled nor aggregated, and diel activity rhythms were absent. Sturgeon did not have a home range and moved 18-6877 m/day. The linear movement was positively correlated with water temperature and independent of the sex of the fish.

Hay-Chmielewski, E.M., and Whelan, G.E. (ed.) 1997. Lake sturgeon rehabilitation strategy. Lake Sturgeon Committee Report. Mich. Dept. Nat. Res. Fish. Div. Spec. Rep. 18: 51 p.

This rehabilitation strategy examined lake sturgeon life history, habitat, goals and objectives, and management issues and recommendations. Its main goal was to "...conserve and rehabilitate self-sustaining populations of lake sturgeon to a level that will permit delisting as a threatened species under the Michigan Endangered Species Act (Section 36505 (1a), Part 324, of Act 451 of 1994)" (pg. 7). The section on lake sturgeon life history provided information on distribution and abundance, reproduction, sub-adult and adult habitat, food, movement, and genetics. Recommendations pertaining to lake sturgeon conservation and rehabilitation are included. They fell into the following categories: general (6 recommendations), harvest (12), barriers (9), sea lamprey control (5), physical alteration of habitat (12), water quality (3), and contaminants (3).

Hayes, J. 2000. Summary of lake sturgeon research efforts in the St. Lawrence and Grasse River systems, p. 8-9. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 3 April 2006].

Hayes, J.S., and Werner, R.G. 1997. Biology, movements and habitat utilization of lake sturgeon (*Acipenser fulvescens*) in the St. Lawrence River, p. 452. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Heacox, C.E. 1952. King of fishes. N.Y. State Conserv. April-May: 18-19.

This was a popular article on sturgeon (*A. sturio oxyrhynchus*, *A. brevirostris* and *A. fulvescens*) and much of what was written has been presented elsewhere in this bibliography. Lake sturgeon, referred to as mud sturgeon, was the most common species in New York. The author referred to juvenile sturgeon as rock sturgeon. The catch in 1950 was 19,522 pounds with a value of \$16,868. The author also made an interesting comment on the difference between the appearance of juvenile and adult "*A. sturio oxyrhynchus*" (the Atlantic sturgeon). Apparently, the juvenile sturgeon were so unlike their parents that many commercial fishermen considered them another species and gave them a special name of "pelican" (pronounced pee-li-can).

Headon, C.M., and Pope, F.M. 1990. Heavy metals program, mercury in reservoirs - cumulative impact of mercury contamination of fish in the Moose River system: a review of MOE data. Ontario Hydro, Environmental Studies and Assessments Department Technical Memorandum 90/4: Pagination unknown.

This document was not available for annotating.

Hedrick, R.P., McDowell, T.S., Groff, J.M., Yun, S., and Wingfield, W.H. 1992. Isolation and some properties of an iridovirus-like agent from white sturgeon *Acipenser transmontanus*. Dis. Aquat. Org. 12: 75-81.

An iridovirus-like agent (WSIV) was isolated from white sturgeon that exhibited signs of the disease. The virus caused cell enlargement and slow degeneration of a recently established cell line from white sturgeon spleen (WSS-2). Juvenile white sturgeon had an 80% cumulative mortality following bath exposures to the virus at concentrations of approximately 10^3 TCID₅₀ g⁻¹ fish for 30 minutes. There were no mortalities among lake sturgeon, striped bass or channel catfish following exposures at the same concentration. However, the agent was recovered from lake sturgeon examined 1 and 2 weeks after exposure. Signs of infections in lake sturgeon were similar to white sturgeon but the cellular hypertrophy was not as prominent. Signs of infection in lake sturgeon included the presence of large amorphous to deeply basophilic cells, and epithelial hyperplasia and degeneration.

Hendry, C. 1990. Cochrane District Fisheries Management Plan 1989-2000. Ontario Ministry of Natural Resources. iv + 30 p.

This general management plan included a brief examination of lake sturgeon. The 1989 harvest of lake sturgeon in the Cochrane District was 500 kg. The production capacity is 600 kg/yr and the projected demand to the year 2000 was 600 kg/yr. Lake sturgeon were to be managed by minimizing the impacts to habitat from dam construction, and the strategy for this was briefly discussed.

Hendry, C., and Chang, C. 2001. Investigations of fish communities and habitat in the Abitibi Canyon Generating Station tailwater. OMNR, Northeast Science and Technology, NEST Information Report **IR-026**: ii + 44 p. Available from www.borealscience.on.ca [accessed 3 April 2006].

This report was comprised of two sections. The first reported on the fish community in the tailwater. Community composition, habitat features, and time of spawning as influenced by flow regulation through the Abitibi Canyon GS were highlighted. The second section contained information on the results of applying a hydraulic-based habitat model to the tailwater area. The process, application of various hydraulic and habitat models used, and outputs from the modeling exercise were summarized. A number of recommendations were given.

Henyey, E., Kynard, B., and Zhuang, P. 2002. Use of electronarcosis to immobilize juvenile lake and shortnose sturgeons for handling and the effects on their behavior. *J. Appl. Ichthyol.* **18**: 502.

The study examined the effects of different immobilization techniques on lake and shovelnose sturgeons. Fish were exposed to a constant low voltage direct current for 5 to 30 minutes. There was no significant difference in time of positive rheotaxis between control and experimental fish. Sturgeon immobilized with 80 mg/L tricaine took significantly longer to recover than those exposed to an electric current or the control fish. Electronarcosis was a useful technique for immobilizing juvenile sturgeon for handling. The recovery time was significantly shorter than for tricaine and the cost of the equipment was roughly \$400 U.S.

Hiatt, R.W., and Strasburg, D.W. 1960. Ecological relationships of fish fauna on coral reefs of the Marshall Islands. *Ecol. Monogr.* **30**: 65-127.

The feeding habits of 56 families of the Marshallese fishes, including 127 genera and 233 species, were reported. The authors classified some sturgeon as grazers, meaning they took some of the substrate along with the algae when they fed. Other sturgeon were classified as browsers, meaning they possessed teeth for biting off bits fronds or filaments above the substrate. Habitat groups and trophic levels were also discussed. A food web showing energy flow in a coral reef was presented.

Hildebrand, K. (ed.) 2004. Recovery. Winter 2003/2004 Upper Columbia White Sturgeon Recovery Initiative [Revelstoke, BC] Newsletter. 4 p. + insert.

This newsletter provided updates on various aspects of the White Sturgeon Recovery Initiative. This issue included an article on the involvement of the Freshwater Fisheries Society of BC in the recovery initiative, a fall/winter research update, and a summary of outreach events that took place over the previous year.

Hildebrand, L., McLeod, C., and Ash, G. 1994. Status of white sturgeon in the Columbia River, British Columbia, Canada, p. 11. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Hildebrand, L., McLeod, C., and McKenzie, S. 1997. Status and management of white sturgeon in the Columbia River in British Columbia. *In* Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

Hill, T. 1998. Status of lake sturgeon in Michigan waters of Lake Huron, reported by commercial fishers 1995-1997. United States Fish and Wildlife Service, Alpena Fisheries Resource Office, Alpena, MI. 14 p. Available from <http://www.fws.gov/midwest/alpena/rpt-sagbay97.html> [accessed 3 April 2006].

This project was started by the Alpena Fishery Resources Office in 1995 to gather information on lake sturgeon needed to determine the

federal listing and develop recovery plans. A detailed description is given of Saginaw Bay in Lake Huron, where the majority of lake sturgeon were caught. Total length, fork length, girth and weight (where possible) were determined and each sturgeon was tagged before release. Biological data were recorded for 112 lake sturgeon from 1995 to 1997. Length ranged from 46 cm to 188 cm, with a mean of 110 cm. Morphological data were summarized.

Hill, T. 1999a. Evaluation of lake sturgeon in the Detroit River as reported by sport anglers. United States Fish and Wildlife Service, Alpena Fisheries Resource Office, Alpena, MI. 7 p. Available from <http://www.fws.gov/midwest/alpena/rpt-detriv98.html> [accessed 3 April 2006].

Three anglers agreed to tag and collect information on lake sturgeon they caught in the lower Detroit River in the fall of 1998. Total length, fork length, girth and weight were determined. The marginal ray of the left pectoral fin was removed for aging, and distal portions of the fin ray were preserved for genetic analysis. A total of 21 lake sturgeon were caught in 25 fishing trips. Fork length ranged from 51 cm to 135 cm, and age ranged from 2 to 22 years. Morphological data were summarized, with a brief mention of substrate and diet.

Hill, T. 1999b. Lake sturgeon status survey in Michigan waters of Lake Huron as reported by commercial fishers. United States Fish and Wildlife Service, Alpena Fishery Resources Office, Alpena, MI. 10 p. Available from <http://www.fws.gov/midwest/alpena/rpt-sagbay98.html> [accessed 3 April 2006].

This study gathered information on lake sturgeon in Lake Huron for determining the federal listing of the species, and developing recovery plans. All lake sturgeon were caught by commercial fishers as by-catch in their trap net fishery. Total length, fork length and girth were measured. The marginal ray of the left pectoral fin was removed for aging and all were tagged. In 1998, 38 lake sturgeon were tagged and measured. The total since 1995 was 129 lake sturgeon. In 1998, fork lengths ranged from 67 cm to 171 cm, and ages from 4 to 59 years. Morphological data were summarized.

Hill, T., and Koproski, S. 2000. Lake sturgeon status survey in Michigan waters of Lake Huron as reported by commercial fishers. United States Fish and Wildlife Service, Alpena Fishery Resources Office, Alpena, MI. 13 p. Available from <http://www.fws.gov/midwest/alpena/rpt-sagbay99.html> [accessed 3 April 2006].

This project gathered data on the lake sturgeon population in Lake Huron to determine the federal listing and develop recovery plans. The majority of lake sturgeon collected were from Saginaw Bay, Lake Huron. Substrates ranged from silt to mostly cobble and rock. Total length, fork length and girth were measured. The marginal ray of the left pectoral fin was removed for aging, the distal portion of the fin ray was preserved for genetic analysis, and all lake sturgeon were tagged. In 1999, biological data were recorded for 45 lake sturgeon. Since 1995, 194 lake sturgeon had been tagged. Fork length for the 1999 lake sturgeon ranged from 41 cm to 185 cm, and age from 3 to 30 years. Morphological data were summarized.

Hill, T.D., and McClain, J.R. 2000. 1999 Activities of the Central Great Lakes Bi-National Lake Sturgeon Group. Presented at Great Lakes Fishery Commission Lake Huron Committee Meeting, Ann Arbor, MI, March 20-21, 2000 and Lake Erie Committee Meeting, Niagara-On-The-Lake, ON, March 29-30, 2000. 55 p.

This report summarized work completed in the 1998 and 1999 open water seasons. A total of 586 lake sturgeon were sampled in 1998 and 568 in 1999. This brought the total number of fish handled to 2,171. The majority of the fish sampled were tagged and returned to the lake. A total of 29 and 37 fish were recaptured in 1998 and 1999, respectively. Many sturgeon in the North Channel were recaptured within 10 days of being tagged, suggesting that these sturgeon were more localized than in other areas. Overall, North Channel recapture rates were higher than of those in other areas. This may reflect a smaller sample size than in southern Lake Huron. In both locations some fish were recaptured 3 to 6 months after tagging, indicating that fish used the same areas in summer and fall. The average size of sturgeon caught in Lake Huron was the same in 1998 and 1999. Ovary weight was collected in 1999 only. Ovaries were collected from harvested mature females in southern Lake Huron. The nineteen ovaries extracted ranged in size from 1.62 to

10.43 kg, and averaged 4.68 kg. They constituted 18.8% of the total body weight, with a range of 11% to 34%. The percentage of the body weight comprised of ovary was positively correlated with the age of the fish. Of the sturgeon sexed, 34% were female. The minimum age at sexual maturity for males in southern Lake Huron was 11 years, and in the North Channel, 10 years. Males matured 2 years earlier in the North Channel than in southern Lake Huron. Similarly, females in southern Lake Huron reached first maturity at age 15 while females in the North Channel reached first maturity at the age of 12.

Hill, T.D., and McClain, J.D. (ed.) 2002. 2000 activities of the Central Great Lakes Bi-National Lake Sturgeon Working Group. United States Fish and Wildlife Service, Alpena Fishery Resources Office, Alpena, MI. 18 p. Available from <http://www.fws.gov/midwest/alpena/rpt-stnib00.html> [accessed 3 April 2006].

In 2000, 648 lake sturgeon were sampled, the majority of these were captured in the extreme southern region of the main basin of Lake Huron. Of this total, 365 were tagged and released. Thirty-nine fish were recaptured that had been tagged in previous years. The consistent capture of young sturgeon suggested continual recruitment in all basins of the lake. Growth patterns and the number of age classes caught in this study were similar to those of the past 5 years. Young lake sturgeon appeared to grow more quickly in southern Lake Huron than in the North Channel. However, once sturgeon reached an age of 24 to 25 years, the variation in weight increased substantially. This variation was more significant among females, and may be related to changes in maturity and the energy invested in the development of reproductive tissue. The act of reproducing and subsequent loss of this weight may also have contributed to this variability. There had been little change in the maturation rate of lake sturgeon in Lake Huron since the initiation of the project in 1995. In southern Lake Huron the majority of male lake sturgeon were mature by 12 years of age, although 100% maturity did not occur until age 18. Females began to mature at 15 y and achieved 100% maturity by age 22 y.

Hill, T.D., and McClain, J.R. 2003. 2001 Activities of the Central Great Lakes Bi-National Lake Sturgeon Group. Presented at Great Lakes Fishery Commission Upper Lakes Committee

Meetings, Milwaukee, WI, March 17-20, 2003, Lake Erie Committee Meeting, Port Huron, MI, March 24-25, 2003, and Lake Ontario Committee Meeting, Niagara Falls, ON, March 27-28, 2003. iv + 44 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-stnib01.pdf> [accessed 3 April 2006].

This report summarized work completed in 2001 by the Central Great Lakes Bi-National Lake Sturgeon Group. Sections included: Assessment of Lake Sturgeon in U.S. Waters of the St. Marys River 2000; Assessment of Lake Sturgeon in U.S. Waters of the St. Marys River 2001; Lake Huron (Georgian Bay and the North Channel) Sturgeon Assessment Update; Integrated Management of Sea Lampreys Related to Lake Sturgeon in the Great Lakes; an untitled summary of work completed on the St. Clair Waterway; Sturgeon Spawning Habitat in the Lake Huron-Lake Erie Waterway; A Non-Lethal Procedure for the Determination of Organic Contaminant Concentrations in Lake Sturgeon; an untitled summary of work completed on the Detroit River; an untitled summary of work completed in the Ohio waters of Lake Erie; Western Lake Erie Juvenile Lake Sturgeon Assessment; and an untitled summary of work completed on the Niagara River.

Hill, T.D., and McClain, J.R. 2004. 2002 Activities of the Central Great Lakes Bi-National Lake Sturgeon Group. Presented at Great Lakes Fishery Commission Upper Lakes Committee Meetings, Ypsilanti, MI, March 22-25, 2004 and Lower Lakes Committee Meetings, Grand Island, NY, March 30-April 1, 2004. iv + 60 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-stnib02.pdf> [accessed 3 April 2006].

This was a summary of the work completed in 2002 by the Central Great Lakes Bi-National Lake Sturgeon Group. Sections included: Assessment of Lake Sturgeon in the St. Marys River 2002; Occurrence of *Argulus* spp. on Lake Sturgeon (*Acipenser fulvescens*) and Walleye (*Stizostedion vitreum*) in St. Marys River (MI/ON); Lake Huron (including Georgian Bay and the North Channel) Sturgeon Assessment Update 2002; an untitled summary of work completed on Lake Huron; Integrated Management of Sea Lampreys Related to Lake Sturgeon in the Great Lakes; an untitled summary of a project to examine the feasibility of archival tags to describe habitat use by lake

sturgeon in southern Lake Huron; an untitled summary of work completed on the St. Clair Waterway; an untitled summary of work completed on the Detroit River; USGS Lake Sturgeon Research in the Huron-Erie Corridor in 2002; A Non-Lethal Procedure for the Determination of Organic Contaminant Concentrations in Lake Sturgeon; Report on Lake Sturgeon Activities for 2002 by the Ohio State University; Conservation Tactics for Endangered Lake Sturgeon; and an untitled summary of work completed on the Niagara River.

Hinks, D. 1943. The sturgeons. Family Acipenseridae, p. 15-18. In *The fishes of Manitoba*. The Department of Mines and Natural Resources, Province of Manitoba.

Distribution, diet, reproduction, growth, and value were summarized for lake sturgeon in Manitoba.

Hoff, J.G. 1979. Annotated bibliography and subject index on the shortnose sturgeon, *Acipenser brevirostrum*. NOAA Technical Report NMFS SSRF-731: iii + 17 p.

This bibliography consisted of 165 references on the classification, distribution, abundance, life history, and ecology of shovelnose sturgeon. Some of the references were related to lake sturgeon.

Hoffman, G.L. 1970. Parasites of North American Freshwater Species. University of California Press, Berkeley and Los Angeles. 486 p.

The following species were listed from lake sturgeon: *Allocreadium* sp., *Crepidostomum lintoni*, *Diclybothrium armatum*, *D. hamulatum*, *Diplostomulum* sp., *Skrjabinopsolus manteri*, *Cucullanus clitellarius*, *Rhabdochona cascadiella*, *Echinorhynchus salmonis*, *Argulus canadensis*, and *A. stizostethi*.

Hoffman, G.L., Raikova, E.V., and Yoder, W.G. 1974. *Polypodium* sp. (Coelenterata) found in North American sturgeon. *J. Parasitol.* 60: 548-550.

Polypodium was reported for the first time in North America. It was found in the eggs of a ripe lake sturgeon, taken from the Black River near Cheboygan, Michigan, on 27 May, 1970.

Abnormal eggs contained the stolon stage of *Polypodium* with characteristic fingerlike tentacles.

Holey, M.E., Baker, E.A., Thuemler, T.F., and Elliott, R.F. 2000. Research and assessment needs to restore lake sturgeon in the Great Lakes: results of a workshop sponsored by The Great Lakes Fishery Trust. i + 37 p. Available from <http://www.glft.org/library/sturgworkshop.pdf> [accessed 3 April 2006].

The goal of this workshop, sponsored by the Great Lakes Fishery Trust and held June 27-28, 2000 in Muskegon, MI, was to identify research and assessment needs to rehabilitate lake sturgeon in the Great Lakes. Four major problems were identified. These included a lack of knowledge on the status and distribution of Great Lakes lake sturgeon populations, a lack of understanding of habitat constraints and the role of habitat structure in the regulation of population structure, a lack of fish passage technologies, and a lack of artificial propagation techniques and other strategies to speed recovery of lake sturgeon populations. Each of these problems was addressed and research approaches developed. The following three presentations were summarized: The Role of the Great Lakes Fishery Trust, Review of Lake Sturgeon in the Great Lakes, and Review of Existing Goals for Lake Sturgeon Rehabilitation in the Great Lakes. A working definition of a healthy or rehabilitated Great Lakes lake sturgeon population was developed based on fish density, age structure and habitat. A questionnaire on the current status of lake sturgeon in the Great Lakes was sent to all workshop participants before the workshop, and the results were summarized. A list of participants and associated contact information was provided. Summaries of the five discussion groups were presented in Appendix D.

Holmes, J.A. 1988. Potential for fisheries rehabilitation in the Hamilton Harbour-Cootes Paradise ecosystem of Lake Ontario. *J. Gt. Lakes Res.* 14: 131-141.

The potential for fish rehabilitation was assessed for the Harbour-Cootes Paradise ecosystem. Habitat loss, hypolimnetic anoxia, contaminated sediments, nutrients, and sediment inputs were all identified as problems. Rehabilitation of the lake sturgeon was unlikely.

Holtgren, J.M., and Auer, N.A. 2004. Movement and habitat of juvenile lake sturgeon (*Acipenser fulvescens*) in the Sturgeon River/Portage Lake system, Michigan J. Freshw. Ecol. **19**: 419-432.

The objectives of this study were to identify juvenile lake sturgeon habitat in the Sturgeon River, to describe movements of juveniles in Portage Lake, and to determine if juvenile movement patterns are related to physicochemical and benthic invertebrate characteristics of habitat. Visual surveys were conducted in the Sturgeon River and fish were captured with dip nets. Each sturgeon was weighed, measured for total length, fork length, girth and mouth width and marked with a punch on a pectoral fin. Gillnets and trotlines were used to capture sturgeon in Portage Lake. For each lake sturgeon, water depth, total length, fork length and girth were recorded. All juveniles and subadults were tagged with a numbered Floy tag, and 5 sturgeon were fitted with radio transmitters (4 external and 1 internal). Twenty lake sturgeon were captured in the Sturgeon River and 4 others were observed. Total lengths ranged from 9.8 to 28.8 cm. Young-of-the-year (YOY) were observed from 10 July to 9 August over riffles and runs of pea gravel or pea gravel and sand. In areas where YOY were captured, benthic invertebrates were low in abundance. Twenty-five lake sturgeon were captured in Portage Lake. Mean water depth at capture sites was 11.3 m for gillnets and 6.8 m for trotlines. The length range for juvenile sturgeon was 21.8 to 83 cm. Capture rates of gillnets and trotlines were compared. Radio tracking revealed that the average linear distance traveled from the initial capture site for all fish was 5.6 km. The average daily movement ranged from 0.3 to 1.6 km and mean distance traveled by all fish was 15.5 km. Depth use was also discussed. Invertebrates collected from Portage Lake at depths used by juveniles were similar to those observed in lake sturgeon diets in other studies.

Holtgren, M., Ogren, S., Baumann, J., Fajfer, S., and Paquette, A. 2005. Implementation of a streamside-rearing facility for sturgeon rehabilitation. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 15 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 3 April 2006].

Holzmann, T.E. 1987. Sturgeon utilization by the Rainy River Ojibwa Bands, p. 155-163. In W. Cowan (ed.) Papers of the Eighteenth Algonquian Conference. Carlton University, Ottawa, Ontario.

The history of sturgeon utilization for the production of isinglass as a tradable item as well as sturgeon flesh for food was reviewed. Sturgeon harvest occurred mostly during summer spawning runs. The occasion also had significant religious and social significance and formed an integral part of Ojibway [Ojibwe, Ojibwa] cultural traditions. Isinglass production provided 7.66% of the total district (Lac la Pluie) return valuation for the period between 1835 and 1869. The average annual production of edible flesh by Ojibway [Ojibwe, Ojibwa] fishermen from the Rainy River from 1823-1885 had been calculated to be 275,415 pounds. Sturgeon oil was considered desirable and was extracted from the head, viscera and gonads. The roe or eggs were also consumed. Sturgeon accounted for over half the caloric values obtained from food sources during 1825-1881, which was later superseded by fur bearing animals.

Holzmann, T.E., and McCarthy, M. 1987. Lake sturgeon (*Acipenser fulvescens*) in the returns of the Hudson's Bay Company Lac la Pluie District. Resource Report prepared for Treaty and Aboriginal Rights Research (TARR) Grand Council Treaty No. 3, Kenora, ON.

This document was not available for annotating.

Holzmann, T., and McCarthy, M. 1988. Potential fishery for lake sturgeon (*Acipenser fulvescens*) as indicated by the returns of the Hudson's Bay Company Lac la Pluie District. Can. J. Fish. Aquat. Sci. **45**: 921-923.

Quantitative district returns of isinglass from the Hudson Bay records for 1823 were converted into the equivalent dressed weight of sturgeon. The weight ratio of isinglass to dressed sturgeon was 1:25. The average annual Ojibway [Ojibwe, Ojibwa] harvest of sturgeon was 141,210 kg for the period 1823-1885, with a maximum annual yield of about 200,000 kg. From 1888 to 1925, the average annual commercial harvest by non-Ojibway [Ojibwe, Ojibwa] was 100,890 kg. Commercial exploitation by non-native fishermen reached a peak in 1899, with a maximum yield of almost 500,000 kg, and then crashed to negligible harvests by 1915. The data

presented was used to support the contention that the potential for a long term sustainable sturgeon fishery existed before non-native over-exploitation decimated stocks.

Holzmann, T.E., and Wilson, W., Chief. 1988. The sturgeon fishery of the Rainy River Ojibway Bands. Smithsonian Columbus Quincentenary Program: "Seeds of the Past", S. Dillon Ripley Center, Smithsonian Institution, Washington, DC. 10 p.

The sturgeon fishery played a significant role in the economy of the Rainy River Ojibway [Ojibwe, Ojibwa] bands in the 19th century. Pemmican was made from pounded sturgeon flesh and sturgeon oil was considered valuable. A giant sturgeon was associated with spirits controlling the fisheries. Sturgeon were harvested using harpoons and spears, and were often tethered through the mouth and gills and kept alive for several weeks. The Ojibway [Ojibwe, Ojibwa] valued isinglass from the sturgeon's air-bladder as an effective binding agent of paint. It was also a sought-after product in Europe for fining beers and wine. Following several unsuccessful attempts, a trade was set up between the Ojibway [Ojibwe, Ojibwa] Indians and the Hudson Bay Company for isinglass. From 1823 to 1885, the sturgeon harvest averaged 311,000 pounds/year, of which the greater portion was reserved for the Ojibway [Ojibwe, Ojibwa] themselves. In 1873, Treaty #3 was signed between the Canadian Ojibway [Ojibwe, Ojibwa] and the Canadian Government. In it, the Ojibway [Ojibwe, Ojibwa] reserved their native rights to the fisheries in the Rainy River. Despite this agreement, Canadian and American non-native fishermen began expanding their operations at the mouth of the Rainy River in the Lake of the Woods, leading to depletion of spawning sturgeon in the Rainy River. Under pressure from non-native fishermen, a portion of the Lake of the Woods was opened to gill and pound nets in 1892, adversely affecting native subsistence. Repeated petitions and appeals by the Ojibway [Ojibwe, Ojibwa] were to no avail and the fishery produced over 1 million pounds dressed weight/year during 1895-1899. However, by 1920 the harvest had dropped to negligible levels. Pollution by the pulp and paper mill at Fort Frances, set up in 1907, degraded the spawning grounds in the Rainy River. The sturgeon population has not recovered to date, despite low harvest quotas for the Ojibway

[Ojibwe, Ojibwa] (2,100 pounds for 1987). Ojibway [Ojibwe, Ojibwa] fisheries were calculated to be 30% more productive than subsequent non-Ojibway [Ojibwe, Ojibwa] fisheries for a similar length of time. There were plans by the Government to rebuild the sturgeon stocks in the Lake of the Woods.

Holzmann, T.E., Lytwyn, V.P., and Waisberg, L.G. 1988. Rainy River sturgeon: an Ojibway resource in the fur trade economy. *The Canadian Geographer* 32: 194-205.

This article discussed the role of the Rainy River lake sturgeon fishery in Ojibway [Ojibwe, Ojibwa] subsistence and commerce. Methods used by the Ojibway [Ojibwe, Ojibwa] to capture sturgeon included hooks and lines, spears, weirs and nets. Each of these methods was discussed. Private and commercial uses of sturgeon and sturgeon products were described and isinglass was discussed in detail. Consequences of the increased harvest by the American commercial fishery formed the conclusion of the article.

Holzmann, T.E., Lytwyn, V.P., and Waisberg, L.G. 1991. Rainy River sturgeon: an Ojibway resource in the fur trade economy, p. 119-139. In K. Abel and J. Friesen (ed.) *Aboriginal Resource Use in Canada*. University of Manitoba Press, Winnipeg, MB.

This article was reprinted from *The Canadian Geographer* 32(3): 194-205, 1988, (see above) with minor editorial revisions.

Hopkins, G.S. 1895. The enteron of American Ganoids. *J. Morphol.* xi: 411-439.

The author described gut morphology of the lake sturgeon and other ganoid fishes. The account began with a brief description of the general organization and anatomical position of the total enteron. The alimentary canal was made up of two ascending and three descending portions, in the following order from the mouth to anus: esophagus, stomach (pyloric portion muscular and thick walled), three pyloric caeca fused into an apparent single organ, intestine and spiral valve of the terminal portion. The esophagus was characterized by the presence of fleshy papillar elevations and stratified epithelium which disappeared shortly before the opening of the pneumatic duct. This was succeeded by a region of columnar epithelium extending to the

pylorus. Contrary to previous reports on acipenserids, the columnar epithelium was described as overlapping the stratified epithelium, supporting the author's contention that the posterior portion of that segment of gut that most other authors have called esophagus was in fact part of the stoma. The greater part of the gastric epithelium was ciliated with numerous, distally opening beaker cells interspersed amongst them. Gastric glands were of the cardiac and pyloric type.

Hopkins, S.H. 1934. The papillose Allocreadidae. III. Biol. Monogr. **13**: 45-124.

A detailed description of the morphology and an account of the taxonomic history of *Crepidostomum lintoni* were provided. This parasite was reported from lake sturgeon of the Great Lakes and St. Lawrence River. The differences between *Acrolichanus* and *Crepidostomum* did not merit the status of separate genera. *Acrolichanus petalosa* was synonymized with *C. lintoni*. The inclusion of specimens from *Ambloplites rupestris* by Faust (1918) was considered "almost certainly erroneous". The descriptions were based on material from *Acipenser fulvescens*. Sexually mature specimens measured 1.3-3.0 mm, with 1-30 ovoid/ellipsoid eggs measuring 50-72 x 25-40 µm, and all morphological features were described. The life cycle was unknown. Landers' report of metacercariae from crayfish *Cambarus* was considered erroneous, since Landers' figure was thought to be metacercariae of *C. cornutum*.

Hopper, M., and Power, G. 1991. The fisheries of an Ojibwa community in northern Ontario. Arctic **44**: 267-274.

Subsistence fishing by the Ojibwa [Ojibway, Ojibwe] community of Webequie, located along the Winisk River in northern Ontario, was studied. Lake whitefish (*Coregonus clupeaformis*), walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*) and suckers (*Catostomus commersoni* and *C. catostomus*) were the most common species caught. Lake sturgeon were attracted special fishing effort. Males older than 40 years were the principle fishermen of the community. Recreational fishing was a source of revenue, while commercial fishing seemed to be waning. Subsistence fishing should be considered when developing management scenarios.

Horne, B.D. 1996. Lower Nelson River forebay monitoring program 1995 - year VII. Unpublished report prepared by North/South Consultants Inc., Winnipeg for Manitoba Hydro, Winnipeg, MB. vii + 41 p.

The 1995 results of an ongoing study to examine the response of fish populations to impoundment of a large northern river were presented. Gill nets were set at 10 locations in the Limestone Forebay between August 16 and September 9. A total of 561 fish were captured. Species included longnose sucker (67.6%), northern pike (11.2%), lake whitefish (7.3%), walleye (4.1%), burbot (4.1%), white sucker (2.3%), sauger (1.2%), lake cisco (1.1%), lake sturgeon (<1%), and shorthead redhorse (<1%). Five lake sturgeon were captured, 4 of which were tagged. All were captured in the Long Spruce Generating Station (G.S.) tailrace/spillway area. This area had a swift current and lake sturgeon had been captured there in previous years of the study, indicating that this area provided the best habitat for lake sturgeon in the Limestone Forebay. One lake sturgeon that was originally tagged in the Limestone Forebay in 1991 was recaptured in the tailrace area below the Limestone G.S. in the spring of 1995. This was the second confirmed lake sturgeon to emigrate downstream of the Limestone Forebay following impoundment. The first was a sturgeon tagged at Brooks Creek in the fall of 1989 and recaptured by a local angler along the south shore of the Nelson River below the Limestone G.S. This emigration may be critical in limiting the lake sturgeon population upstream of the Limestone G.S. Results were compared to those from previous years.

Horne, B.D., and Baker, R.F. 1993. A fisheries survey of the Limestone Forebay, 1992 - Year IV. North/South Consultants Inc. Winnipeg, MB. vii + 48 p.

This report highlighted the results of the fourth year of a multi-year program to monitor changes in fish populations in the Limestone Forebay. Species composition, relative abundance, muscle mercury concentration, and life history were to be analyzed. A total of 487 fish were gillnetted in the forebay. Mooneye, lake sturgeon, burbot, sauger, lake cisco, and freshwater drum composed less than 2% of the total catch, showing the evolution of the river from a lotic to a lentic environment.

Horne, B.D., and MacDonell, D.S. 1995. Lower Nelson River forebay monitoring program 1994 - year VI. Unpublished report prepared by North/South Consultants Inc., for Manitoba Hydro., Winnipeg, MB. vii + 41 p.

The 1994 results of a multi-year study to monitor the response of northern fish populations to impoundment of a large river were presented. A total of 479 fish, representing 13 species, were captured in gillnets set at 10 sites in the Limestone Forebay. Five lake sturgeon (1.1% of catch) were captured, all in the Long Spruce Generating Station spillway in the upper area of the Limestone Forebay. Results were compared to those from previous years.

Horns, W.H., Bronte, C.R., Busiahn, T.R., Ebener, M.P., Eshenroder, R.L., Gorenflo, T., Kmiecik, N., Mattes, W., Peck, J.W., Petzold, M., and Schreiner, D.R. 2003. Fish-community objectives for Lake Superior. Gr. Lakes Fish. Comm. Spec. Publ. 03-01: 78 p. Available from www.glfc.org/pubs/SpecialPubs/Sp03_1.pdf [accessed 3 April 2006].

Lake sturgeon were included in a list of prey species of concern for fisheries management on Lake Superior. With the successful control of sea lamprey populations the offshore fish community had returned to conditions similar to pre-modern times.

Houston, J.J. 1984. Status of the lake sturgeon (*Acipenser fulvescens*) in Canada. Unpublished report prepared for the Committee on the Status of Endangered Wildlife in Canada. 44 p.

The published version of this document is annotated below (see Houston 1987).

Houston, J.J. 1987. Status of the lake sturgeon, *Acipenser fulvescens*, in Canada. Can. Field Nat. 101: 171-185.

The biology and population dynamics of lake sturgeon were reviewed. The species had been listed as endangered by CITES, but was delisted in 1983. The decline of sturgeon fisheries was reviewed and various existing populations were compared. Manitoba was singled out for having (with the exception of Lake Winnipeg) a relatively healthy lake sturgeon population, particularly in the Winnipeg River. The South Saskatchewan River had historically produced 75% of landings in Saskatchewan, but

overfishing and high mercury levels forced the closure of the fishery in 1969. It was reopened in 1973 in Cumberland Lake and Churchill River. The average weight of sturgeon caught in Alberta was said to be 14-22 kg, prior to 1940, when the fishery closed. It reopened in 1969 under stringent regulations and the population was considered possibly healthy and similar to historic levels.

Howell, B.R. 1994. Fitness of hatchery-reared fish for survival on the sea. Aquac. Fish. Manag. 25: 3-17.

Hatchery-reared fish were not as well equipped as their wild counterparts for survival in the natural environment. The characteristics of hatchery-reared fish that may have reduced their survival in the wild, and adjustments that could be made to improve their success were reviewed.

Howell, J.A. 1914. Forty-sixth annual report of the [Canada] Department of Marine and Fisheries. Sessional Paper 22: 258-262.

The fishing of sturgeon in Clearwater Lake was reported for the first time.

Howell, J.A. 1916. Forty-eighth annual report of the Fisheries Branch [Canada]. Sessional Paper 39: 214-222.

Pine Falls, MB was noted as a spawning site for sturgeon and whitefish.

Hubbs, C.L. 1917. *Acipenser fulvescens* Rafinesque, the great lake sturgeon. Copeia 1917: 48.

It was argued that the first species designation of lake sturgeon as *A. fulvescens* by Rafinesque (1817) had been overlooked in favour of the then more popular designation of *A. rubicundus* by Le Sueur (1818). The original 1817 description by Rafinesque was reprinted in whole.

Hughes, T.C., Lowie, C.E., and Haynes, J.M. 2005. Age, growth, relative abundance, and scuba capture of a new or recovering spawning population of lake sturgeon in the lower Niagara River, New York. N. Am. J. Fish. Manag. 25: 1263-1272.

This study collected information on age, growth, and catch per unit effort (CPUE) of lake sturgeon in the lower Niagara River; began assessing the threatened lake sturgeon population in the river; and examined the efficiency of using scuba divers to capture lake sturgeon. A total of 67 lake sturgeon were captured between 1998 and 2000 by gillnets, setlines or diving. Ten were caught by divers (CPUE=1.50 fish/h), 30 were caught by gillnets (CPUE=0.012 fish/h), and 27 were caught by setlines (CPUE=0.011 fish/h). Bait used on setlines is also discussed. Captured lake sturgeon ranged in age from 1 to 23 years; 47 of the 61 aged fish were less than 10 years old. Scuba diving was an efficient method for capturing lake sturgeon less than 1000 mm in length. The lake sturgeon population of the lower Niagara River likely represents a new or recovering population, since it is composed mostly of young fish. Growth rates were equal to, or greater than, those of other Great Lakes populations. Continued listing of the population as threatened, and continued closure of the commercial and recreational fisheries was recommended.

Hujik, B. 2004. Stocking evaluation, lake sturgeon - sportfish restoration status reports, July 2003 - June 2004. Wisconsin Department of Natural Resources, Madison, WI. 1 p.

This document was not available for annotating.

Huner, J.V. 1982. Pond culture of American eel, sturgeon, and Sacramento blackfish? Farm Pond Harvest **Winter**: 10-11, 16.

Sturgeon culture techniques and problems were discussed. The major problems identified included the actual spawning of adults and the fact that the eggs are very sticky and must be washed in a silt suspension for 20 to 30 minutes to prevent clumping. Atlantic, white and green sturgeon culture programs in the U.S. were discussed.

Hunter, J.G., Kidd, B.T., Greendale, R., Baxter, R., and Morin, R. 1976. Fisheries resources of the lower reaches and coastal regions of Eastmain, La Grande, Roggan, and Great Whale rivers from 1973 to 1975, p. 299-321. *In* James Bay Environment 1976 Symposium. Environment Canada, Ottawa.

Lake sturgeon were present in the Eastmain and La Grande rivers and were likely present in the Broadback River. Lake sturgeon were not found in the Rogan, Great Whale and Mackenzie rivers. A total of 25 lake sturgeon were tagged in the Eastmain River, but none were recaptured.

Iskov, M.P. 1978. Results of studies in fish parasite fauna from the Dneper till the regulation of the flow by the hydroelectric power station dam, p. 34-44. *In* A. P. Markevich (ed.) Problems of Hydroparasitology, Naukova Dumka, Kiev.

This book chapter was not available for annotating.

Izuka, T., Hara, H., and Suguro, N. 2000. Conversion of artificial feed on early life history stages of the lake sturgeon, *Acipenser fulvescens*. Bull. Kanagawa Prefect. Fish. Res. Inst. 5: 17-24.

Experiments were conducted to convert 6-month old lake sturgeon from natural feed to artificial feed. Frozen bloodworms and water fleas were well consumed. Formula feed and frozen mysids were consumed the least and were accompanied with high fish mortality, suggesting that the fish had imprinted on live organisms during early stages of exogenous feeding. Eighteen-month old lake sturgeon were successfully weaned off live food using a paste formula made of bloodworm, mysid, and trout dry diet, but growth fluctuated widely.

Jackson, J.R., Brooking, T.E., and VanDeValk, A.J. 2004. Lake sturgeon restoration in Oneida Lake, New York: stocking, habitat use, and life in the fast lane. *In* Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, WI. Pagination unknown. [Abstract only].

Oneida Lake was one of several water bodies included in a stocking program initiated in 1995. It appeared that the sturgeon were doing very well in this lake, based on data collected on length-at-age in relation to growth rate, length-weight relationships, and sexual reproduction capabilities. A habitat-specific gill net survey had overall catch rates of 0.3 sturgeon/hr over 2 years. Highest catches were observed over sand and shoal substrates. Diets consisted of amphipods, snails, and zebra mussels.

Jackson, J.R., Brooking, T., and Van De Valk, T. 2005. Lake sturgeon restoration in Oneida Lake: stocking, habitat use and life in the fast lane. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 41 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 4 April 2006].

Jackson, J.R., VanDeValk, A.J., Brooking, T.E., VanKeeken, O.A., and Rudstam, L.G. 2002. Growth and feeding dynamics of lake sturgeon, *Acipenser fulvescens*, in Oneida Lake, New York: results from the first five years of a restoration program. *J. Appl. Ichthyol.* **18**: 439-443.

Studies indicated a large and rapidly growing juvenile fish population. Lake sturgeon in the 1 to 5 year age range were growing 145 mm per year. Weight-based measurements indicated a population with ample food resources. Amphipods were the dominant diet item and zebra mussels were an important diet component for juveniles larger than 700 mm. Impacts of lake sturgeon on zebra mussel populations should be examined further. With the data available it appeared that Oneida Lake could support a self-sustaining sturgeon population, provided that there was suitable spawning habitat.

Jahangir, Z.M.G.S., and Eckhardt, R.A. 2000. Microinjection as a means of developing a molecularly tagged stock of lake sturgeon, *Acipenser fulvescens* (Rafinesque), p. 13. In C. Lowie (ed.) Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization. Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report 2000-01. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 4 April 2006].

James Bay and Northern Québec Native Harvesting Research Committee (JBNQNHRC). 1978. Fish, p. 175-197. In Research to establish present levels of harvesting by native peoples of northern Québec. Part 1, Harvests by the James Bay Cree. James Bay and Northern Québec Native

Harvesting Research Committee, Québec City, Québec.

This document provided Native reported and projected harvest statistics by species and community for James Bay and Northern Québec from 1975 to 1976. Species included whitefish, northern pike, speckled trout, lake trout, dore, sturgeon, sucker, char and burbot. Communities included Great Whale, Fort George, Paint Hills, Eastmain, Rupert House, Mistassini and Waswanipi. A total of 1,323 sturgeon were harvested by all communities between 1975 and 1976. The communities with the highest harvest were Fort George and Waswanipi with 40.51% and 38.85%, respectively. Table 19 compares the 1975-76 harvest by community with the "best estimate" for 1974-75, and overall showed a 61% decrease in sturgeon harvest.

James Bay and Northern Québec Native Harvesting Research Committee (JBNQNHRC). 1982. Fish, p. 146-199. In The wealth of the land. Wildlife harvests by the James Bay Cree, 1972-73 to 1978-79. James Bay and Northern Québec Native Harvesting Research Committee, Québec City, Québec. xxxix + 811 p.

Estimated wildlife harvests of the Cree and Inuit of northern Québec were presented from 1974 to 1979. An estimated 11,553 sturgeon were harvested by all communities over the years in question. Mean estimates of annual harvests by community were as follows: Fort George - 615; Paint Hills - 155; Eastmain - 94; Rupert House - 229; Nemaska - 63; Mistassini - 366; and Waswanipi - 789. Estimated harvests were also presented by year. Eighty-seven percent of lake sturgeon were harvested in summer-fall, with the remaining 13% being harvested in winter.

Jatteau, P. 1998. Étude bibliographique des principales caractéristiques de l'écologie des larves d'acipenséridés. *Bull. Fr. Pêche Piscic.* **350-351**: 445-464.

The main ecological features of acipenserid larvae were reviewed. They were classified into 4 stages according to age, with swimming position activity and position in relation to the substrate used as criteria. Foraging activity was found to be based on gustatory sensitivity at the beginning of mixed feeding. Olfactory sensitivity was more important for older larvae. Vision was insignificant during feeding behavior. Sturgeon

larvae ate mainly insect larvae, particularly chironomids. Drift and migration of larvae could be explained by a limited number of habitats and feeding disponibility.

Johnson, D.A., and Weisser, J.W. 1996. Sensitivity of lake sturgeon (*Acipenser fulvescens*) to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) in field and laboratory exposures, p. 59. *In* The 39th Conference of the International Association for Great Lakes Research. May 26-30, 1996. Erindale College, University of Toronto, Mississauga, ON. [Abstract only].

Johnson, D.A., Weisser, J.W., and Bills, T.D. 1999. Sensitivity of lake sturgeon (*Acipenser fulvescens*) to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) in field and laboratory exposures. Gr. Lakes Fish. Comm. Tech. Rep. 62: 23 p. Available from www.gllc.org/pubs/TechReports/Tr62.pdf [accessed 4 April 2006].

The effects of 3-trifluoromethyl-4-nitrophenol (TFM), a lampricide, on lake sturgeon were investigated. Concentrations of TFM roughly 1.33 times the LC99.9 of sea lamprey larvae were not lethal to lake sturgeon. Laboratory analysis revealed that lake sturgeon were more sensitive than northern pike (*Esox lucius*), muskellunge (*Esox masquimongy*), and rainbow trout (*Oncorhynchus mykiss*). Although pH affected the toxicity of TFM to lake sturgeon, fluctuations in total alkalinity had minimal effect. This allowed stream treatment without harming lake sturgeon populations. Lampricide was applied to the river to kill larval sea lampreys in 1989 and 1994 with few dead non-target species and no dead lake sturgeon.

Johnson, J.E. 1987. p. 1-4 & 39. *In* Protected Fishes of the United States and Canada. American Fisheries Society, Bethesda, Maryland.

Eight sturgeon taxa were listed as receiving legal protection and classified as species of special concern due to low numbers, limited distributions, or recent declines in population numbers. The listed taxa were shortnose, lake, Atlantic, gulf, white, pallid, shovelnose, and Alabama shovelnose sturgeon. The states and provinces of the U.S. and Canada where they received legal protection were also listed.

Johnson, J.H., Dropkin, D.S., LaPan, S.R., McKenna, J.E., Jr., and Klindt, R.M. 1998. Age and growth of lake sturgeon in the upper St. Lawrence River. J. Gt. Lakes Res. 24: 474-478.

The growth of lake sturgeon in the upper St. Lawrence River (below Robert Moses Dam near Massena, New York) was similar to that of the same population 25 years earlier. Significant differences in the elevations of regression models between males and fish of unknown sex in both data sets suggested sexual dimorphism in growth at younger stages.

Jolicoeur, P. 1985. A flexible 3-parameter curve for limited or unlimited somatic growth. Growth 49: 271-281.

This paper described the derivation of a simple 3-parameter asymptotic growth curve, $X=A/(1 + D/t^C)$ from the logistic curve, $X=A/[1 + D/\exp(Ct)]$, by replacing time (t) with its natural logarithm. This curve was more flexible than other curves of its kind (Gompertz, logistic) since it passed through the origin. This derived curve also showed better numerical convergence and had a variable inflection point. When growth appeared unlimited, within the range of the data, the curve became similar to allometry with respect to time. Two sets of data, one from elephant seals and the other from lake sturgeon from Lac des Deux Montagnes, were used to illustrate the curve. The present sample of lake sturgeon were from a population which did not include specimens older than 25 years because the fish in Lac des Deux Montagnes were eradicated by a peak of industrial pollution in 1950. Growth was only marginally asymptotic for female lake sturgeon. While the asymptotes were higher than the maximum length and weight observed in the sample, they did not reach the maximum dimensions of the species.

Jollie, M. 1980. Development of head and pectoral girdle skeleton and scales in *Acipenser*. Copeia 1980: 226-249.

The development of the head and pectoral bones of *Acipenser fulvescens* and *Acipenser ruthenus* was described, based on cleared and stained specimens and serial sections. The stages were designated 0 (14 mm lake sturgeon) through to 9 (120 mm sterlet) and 10 (full grown sturgeon or sterlet). The description began with the lateral line system. In the smallest (14 mm) specimens studied, the nasal

capsule was undivided and the first line of the lateral line system was the temporal. This was followed by the formation of a closed ethmoid canal in stage 2 (14-15 mm) opening anteriorly and bilaterally on the snout. The various sensory structures, canals, and lines underwent modification as development proceeded. During the development of the cartilaginous elements of the head, five separate elements were chondrified in the hyoid arch in stage 0 sturgeon specimens. The formation of the snout bones was described and it was concluded that the characteristic ventral keel has no homology with the vomer of other fishes, as might be supposed. The canal bones of the intraorbital line and the bones behind the eye were discussed, the latter arranged as in *Amia* or gars. Of the other head bones described, the dermosphenotic was reminiscent of the palaeoniscoids. The bones of the occipital line, preopercular canal and those of the cheek were described and the status of "branchiostegal rays" was discussed. The bones of the mouth were uniquely developed. A premaxilla was lacking and the margins of the maxilla were closely related to the margins of the palatoquadrate. The maxilla along with its 8 teeth (4 on each side) formed early (stage 0), and the teeth were gradually lost. The palatopterygoid possessed 4 teeth at stage 0. This increased to 15 teeth by stage 4 (23 mm). The dentary was also present in stage 0 and its teeth increased in number to six, and subsequently dropped off as development proceeded. The prearticular was well developed in fully grown lake sturgeon but its absence in developing sterlet larvae was inexplicable. The endocranium was massive and entirely without ossification even in the oldest lake sturgeon studied. The elements of the pectoral girdle were described individually and differences were noted between the postcleithrum of the lake sturgeon and the sterlet. Some differences were noted in scute development between the lake sturgeon and sterlet. Variation in pattern of the roof bones in the head was noted among specimens of lake sturgeon, considered to be in accordance with such phenomena reported in Atlantic sturgeon. An abnormality due to confluence of anterior nasal openings in one specimen of lake sturgeon was discussed in relation to the development of associated bones.

Jolliff, T.M., and Eckert, T.H. 1971. Evaluation of present and potential sturgeon fisheries of the St. Lawrence River and adjacent waters. New York Department of Environment Conservation, Cape Vincent Fisheries Station, Cape Vincent, NY. 113 p.

This report described a two year study begun in 1969 to determine the present and potential value of the St. Lawrence River sturgeon resources. The report was divided into three sections under Jobs I, II and III. Job I reviewed the past and present sturgeon fisheries of the St. Lawrence River. Numbers of trap and bait lines were highest between 1923 and 1926, and steadily declined thereafter, as did harvests (maximum of 23,500 lbs in 1923). Licenses increased to a maximum of 178 in 1949 and then decreased to 35 in 1963. Canadian harvest data from 1964-1969 indicated a decline over these years. Attempts to evaluate present sturgeon populations proved statistically difficult because of sampling problems, which were discussed. The sturgeon population in the upper areas may have been much lower than in the area below Robert Moses Dam. Sturgeon captured below the dam (139) ranged in age from 7 to 38 years, and 80% of the fish were between 9 and 13 years old. Relationships between age (A, years), length (L, mm) and weight (W, g) were given by the equations $\log W = -0.433 + 1.433 \log A$; $\log L = 1.070 + 0.422 \log A$; and $\log W = 4.122 + 3.405 \log L$. The youngest mature and ripe male was 9 years old. Stomach contents of the three fish examined consisted of snails and alewives (*Alosa pseudoharengus*). Seven dams located on the St. Lawrence River and its five tributaries were likely the main causes of the decline in sturgeon populations. Regulations were recommended to improve the management of sturgeon stocks, including a closed season from 1 April-30 June, closure of sturgeon fisheries above and below Robert Moses Dam for 15 and 25 years respectively, increasing the legal harvest size to 54.4 inches (fork length), and other measures. A summary of the Russian sturgeon culture program was presented in Appendix I.

Jones, A. 2005. Saskatchewan's rare fish. [Saskatchewan] Environment Newline **June 20**: 4 p. Available from www.se.gov.sk.ca/media/ [accessed 4 April 2006].

This short article provided a general description of lake sturgeon, gave their distribution in Saskatchewan and discussed recovery problems.

Jude, D.J. 1982. Family Acipenseridae, sturgeons. pp. 38-44. In N. A. Auer (ed.) Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Gr. Lakes Fish. Comm. Spec. Publ. 82-3. Available from www.glfc.org [accessed 4 April 2006].

This report contained a two page (p. 42-43) section on lake sturgeon larvae. Illustrations of a yolk-sac larva, an 18.5 mm larva, and a 22 mm larva (dorsal and ventral aspects) were included. The 18.5 mm larva showed prominent pectoral fins, a mouth bordered by fleshy lips, and barbels. The 22 mm larva had the distinctive shape of the adult sturgeon.

Jude, D.J., and Pappas, J. 1992. Fish utilization of Great Lakes coastal wetlands. J. Gt. Lakes Res. 18: 651-672.

Fish species were separated according to their association with open water of each of the Great Lakes and nine coastal wetlands. There were 113 species in 25 families. Three species complexes were determined: a Great Lakes taxocene; a transitional community which used open water, nearshore and wetlands; and a wetland taxocene. Lake sturgeon were classified as a Great Lakes species. Many of the wetland areas had been degraded and were dominated by silt and turbidity-tolerant fish species. Recommendations were made for further research into the Great Lakes coastal wetland areas.

Kelly, P.A. Date unknown. Lake sturgeon suitability modeling, and coverage generation in Pools 5A and 8 of the Mississippi River. Upper Mississippi Science Center, La Crosse, WI. 12 p. [Unpublished].

This article described a radio telemetry study completed in pools 4 through 10 of the upper Mississippi River. GIS analysis was used to determine the spatial relationships between lake sturgeon and their habitat. Habitat suitability modeling was then completed to determine if the data could be used to model species' habitat. Lake sturgeon were most often found in areas of high suitability or in close proximity to them.

Kelso, J.R.M., and Cullis, K.I. 1996. The linkage among ecosystem perturbations, remediation, and the success of the Nipigon Bay fishery. Can. J. Fish. Aquat. Sci. 53: 67-78.

Populations of walleye (*Stizostedion vitreum*), and lake sturgeon (*Acipenser fulvescens*) were extirpated from Nipigon Bay of Lake Superior due to exploitation and ecosystem perturbations. In addition, lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), and northern pike (*Esox lucius*) populations declined, while lake whitefish (*Coregonus clupeaformis*) and lake herring (*Coregonus artedii*) populations increased. Lake whitefish and lake herring did not interact with tributaries and nearshore habitats as often as the other fish, lessening their susceptibility to stressors. Eutrophication, airborne contaminants, and exploitation have impaired the success of these species.

Kelso, J.R.M., Steedman, R.J., and Stoddart, S. 1996. Historical causes of change in Great Lakes fish stocks and the implications for ecosystem rehabilitation. Can. J. Fish. Aquat. Sci. 53: 10-19.

This analysis of changes in the Great Lakes fisheries from 1879 to 1990 concluded that changes in the species composition of harvests were indicative of the disintegration of native fish communities, with evidence of recovery in recent times. Habitat disruption and eutrophication appeared to decrease in intensity and scale. Reevaluation of conservation goals, both local and lake wide, was deemed appropriate because of their different scales of management action and the poor understanding of species responses. Proposed scales of habitat enhancement were likely to only affect small and nondiadromous fish or localized populations, such as lake sturgeon and walleye.

Kempinger, J.J. 1988a. Early life history of lake sturgeon, p. 79-112. In Prog. Rep. Wis. Dept. Nat. Res. Stud. 227.

This document was not available for annotating.

Kempinger, J.J. 1988b. Spawning and early life history of lake sturgeon in the Lake Winnebago system, Wisconsin, p. 110-122. In R. D. Hoyt (ed.) 11th annual larval fish conference, June 1-3, 1987, Houghton, MI. American Fisheries Society Symposium 5, Bethesda, MD.

Spawning behavior and the early life history of the self-sustaining lake sturgeon population in Lake Winnebago were studied. The spawning site at the Shawano Dam on the Wolf River was chosen as the study area. The study spanned the years 1981 to 1984. Fish spawned over boulders in rapid currents at the foot of the dam, and preferred a shoreline with relatively strong current and shallow water. Six to eight males accompanied one female. Eggs ran for 7-10 seconds while the males vibrated simultaneously alongside the female. A spawning foray consisted of several such acts of egg release, following which the group dispersed into deeper waters. Spawning was biphasic. Depending upon the year, the initial/peak spawning took place at water temperatures ranging from 8.3 to 16.1°C, with a secondary spawning peak at water temperatures of 13.0-23.3°C. Spawning may have been interrupted by a drop in temperature, producing cold water fronts which caused the sturgeon to disperse. Females spawned every 4-6 years while males spawned every other year. Eggs were randomly scattered during spawning, adhered to rocks and other available substrates, and were most abundant in fast flowing water. Eggs were eaten by crayfish, *Necturus*, *Moxostoma*, common carp, and sturgeon. Other causes of mortality included fungus over-growth, sediment deposition and water level fluctuation. The data also indicated that the egg survival (to hatching) was better at shorter incubation times with a gradual warming of water during pre-spawning, spawning, and post-spawning. Yolk-sac larvae were nocturnal drifters, and nightly catch rates were nine times higher than daytime catches. A total of 1,232 larval sturgeon were netted over 4 years, 150 m downstream of the dam. Length ranged from 8-22 mm. Figures of various larval stages were provided. Larval stomach contents included baetid and chironomid larvae. Growth (in length) of the larvae was approximately linear up to 20 mm. The regression line slopes for the relationship between total length of larvae and their age varied significantly among years and indicated a direct proportionality with water temperature.

Kempinger, J.J. 1996. Habitat, growth, and food of young lake sturgeons in the Lake Winnebago system, Wisconsin. *N. Am. J. Fish. Manag.* **16**: 102-114.

The habitat, growth, and food of young lake sturgeon were studied from 1981-1987 in the

Lake Winnebago system. Age-0 fish were captured in areas with a detectable current, pea-sized gravel substrate and coarse sand, and no rooted vegetation. The sturgeon were solitary and stayed in close contact with the substrate, oriented upstream, and fed on benthic organisms. During their first summer, the sturgeon consumed principally Baetidae nymphs and Diptera larvae. The primary food items of 81 sturgeon caught in lake Winnebago were *Chironomus plumosus*, *Leptodora kindtii*, and *Daphnia* spp.

Kempinger, J.J., Otis, K.J., and Ball, J.R. 1998. Fish kills in the Fox River, Wisconsin, attributable to carbon monoxide from marine engines. *Trans. Am. Fish. Soc.* **127**: 669-672.

In 1988, more than 58 fish kills (including lake sturgeon) occurred from April to October along the Fox River. Carbon monoxide was found to be the cause, and the origin of the toxicity was traced back to a motor endurance testing facility. Blood carboxyhemoglobin levels ranged from 32-97%. Unfortunately, fish kill episodes were enhanced by flow reversals in the Fox River, a result of seiches from Lake Winnebago. Although motor testing continued, it was monitored for compliance.

Kerr, S.J. 2002. Atlas of lake sturgeon waters in Ontario. Ontario Ministry of Natural Resources, Peterborough, ON. 12 p.

This document listed all of the 229 water bodies in Ontario known to contain lake sturgeon. This information was compiled from a variety of sources including the provincial fisheries database of lakes and streams (AHIS) and fisheries assessment projects (FISHNET).

Kerr, S.J., and Bowman, J. 2003. A literature review of lake sturgeon regulations in North America. Prepared by the Fish and Wildlife Branch, Peterborough, ON. i + 30 p.

This literature review of background reference material was organized under seven general categories: sturgeon fisheries, general regulations, open/closed seasons, catch and possession limits, size limit regulations, fish sanctuaries, and angler attitudes and compliance. There were complete abstracts and summaries of research available, and citations where a copy of the document was unavailable.

Kerr, S.J., and LeTendre, G.C. 1991. The state of the Lake Ontario fish community in 1989. Gr. Lakes Fish. Comm. Spec. Publ. **91-3**: 40 p. Available from www.glfc.org/pubs/SpecialPubs/Sp91_3.pdf [accessed 4 April 2006].

Changes in the fish community of Lake Ontario and its outlet, the St. Lawrence River, were discussed. Among several of the species highlighted, lake sturgeon were mentioned as being extirpated or depressed.

KGS Group, Environmental Applications Group, and Northwest Hydraulic Consultants Ltd. 1991. Evaluation of fish habitat mitigation at six hydrotechnical projects. Prepared for the Department of Fisheries and Oceans, Central and Arctic Region, Winnipeg, Manitoba. Various pagination.

This study assessed the effectiveness of the fish habitat mitigation and instream flow measures proposed for each of six hydrotechnical projects, and whether these measures fulfilled Department of Fisheries and Oceans (DFO) policies regarding fish habitat. The conclusions regarding the applicability and effectiveness of these measures were discussed. The physical features of streams were highlighted, as well as previous mitigation methods used. Instream flow needs downstream of hydrotechnical developments and flushing flows were discussed. Various methods and models for assessing and predicting the response of fish and aquatic life to changes in their environment were reviewed. In the second part of the report, each of the six hydroelectric projects was evaluated in terms of their impacts and mitigation measures and the "no net loss" policy of DFO. A lack of long term baseline data and quantification of pre-and post-development productive capacity were identified as shortcomings for all of the projects. Utilization of an issue rather than an ecosystem approach also hampered the projects.

Kilambi, R.V. 1968. Analysis of the growth of the pacific herring (*Clupea pallasii*), lake sturgeon (*Acipenser fulvescens*) and white sturgeon (*Acipenser transmontanus*) by the Parker-Larkin and Von Bertalanffy methods, p. 297-314. In Proc. 21st Annu. Conf. S.E. Assoc. Game Fish. Comm., New Orleans, Louisiana, 1967.

The author discussed methods of assessing fish growth, and outlined the equations developed by Von Bertalanffy and Parker-Larkin. Data for lake sturgeon were from Manitoba. The oldest sturgeon was 55 years, but length measurements were for the first 21 years only. Observed and predicted lengths agreed well with the Parker-Larkin method but were underestimated by the Bertalanffy method. There were large annual size increments in the first six years and relatively constant increments thereafter.

Killgore, K.J., and Chan, M.D. 1996. North American sturgeon: implications for the Corps of Engineers. Environmental Impact Research Program Information Bulletin **96-1**: 7 p.

The life history, ecology, taxonomy, and status of North American sturgeon species were discussed. The lake sturgeon was described as a freshwater species that is distributed from the Great Lakes and Hudson-James Bay to the Mississippi River basin. It was not listed federally, but was listed in: Illinois, Indiana, Iowa, Michigan, Missouri, Nebraska, New York, Ohio, Pennsylvania, Tennessee, and Vermont. Issues faced by the Corps of Engineers regarding sturgeon were also discussed. These included dredge entrainment, long term habitat change by water control structures and dredging, barriers to migration caused by structures, and short term habitat change from construction and maintenance. The article concluded with a section on research priorities that did not include lake sturgeon.

Killgore, K.J., Maynard, S.T., Chan, M.D., and Morgan, R.P., II. 2001. Evaluation of propeller-induced mortality on early life stages of selected fish species. N. Am. J. Fish. Manag. **21**: 947-955.

Larval lake sturgeon was one of several fish species subjected to sheer stress. Mortality was a linear function of sheer stress for all species and life stages, and the mortality rate appeared to depend on larval size. Lake sturgeon larvae are smaller, and thus had a higher mortality rate than shovelnose sturgeon and paddlefish.

Kimura, S. 1992. Wide distribution of the skin type I collagen $\alpha 3$ chain in bony fish. Comp. Biochem. Physiol. **102b**: 255-260.

Subunit chains of skin type 1 collagens were isolated from non-teleostean fish and examined. The $\alpha 3(1)$ gene, previously thought to only occur in teleostean fish also occurred in white sturgeon, a chondrosteian fish. This gene seems to have been created from a duplication of the $\alpha 1(1)$ gene near the time of adaptive radiation of bony fish.

Kincaid, H. 2000. Genetic considerations for captive breeding programs to preserve genetic variability, p. 8-9. *In* C. Lowie (ed.) Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization. Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report 2000-01. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 4 April 2006].

King, T.L., Lubinski, B.A., and Spidle, A.P. 2001. Microsatellite DNA variation in Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and cross-species amplification in the Acipenseridae. *Conserv. Genet.* 2: 103-119.

Although the focus of this study was on Atlantic sturgeon, the authors isolated six microsatellite loci on ten other sturgeon species, including lake sturgeon. The genetic diversity and population structure of Atlantic sturgeon were assayed using three polymorphic Aox markers and four markers from lake sturgeon. The mean diversity of Atlantic sturgeon was greatest in Chesapeake Bay and lowest in the St. Lawrence River. There appeared to be at least six subpopulations of Atlantic sturgeon, suggesting isolation by distance and philopatry. Hierarchical gene diversity analysis indicated significant genetic population structure at every level. A variety of tests showed that the Chesapeake Bay population was a mix of sub-adult sturgeon from the northern and southern Atlantic coast populations. Two Canadian populations, from which only a single mtDNA haplotype has been reported, showed significant genetic diversity.

Kirsch, P.H., and Fordice, M.W. 1889. A review of the American species of sturgeons (Acipenseridae). *Proc. Acad. Nat. Philadelphia*, Part II: 245-257.

The taxonomy of sturgeon found in American waters was reviewed and six species were distinguished. A list of synonyms with their corresponding references was provided for each species. The lake sturgeon appeared as *Acipenser rubicundus* Le Sueur, 1818. Twenty-six synonyms were listed for *A. rubicundus*, of which only one synonym, *Dinectus truncatus* Rafinesque, appeared under a generic name other than *Acipenser*. Sixteen of the synonyms were after Dumeril (all from the same reference: *Hist. Poiss.* II, 1870), three after Agassiz (Lake Superior, 1850), one each after Richardson (Fauna Bor. Amer. 1836), Gunther (Cat. Fish. Brit. Mus. VIII, 1870) and Le Sueur (Trans. Am. Phil. Soc. 1818) while the remaining were after Rafinesque (*Ichthyol. Ohiensis*, 1820). A brief note followed on its habits. This is a valuable source for early taxonomic literature on lake sturgeon and the interested reader is directed to it for minor references not annotated in this bibliography.

Klar, G., and Schleen, L. 2000. Integrated management of sea lampreys in the Great Lakes 2000. United States Fish and Wildlife Service, Sea Lamprey Control. 68 p.

This document was not available for annotating.

Klar, G., and Schleen, L. 2002. Integrated management of sea lampreys in the Great Lakes 2002. United States Fish and Wildlife Service, Sea Lamprey Control. 70 p.

This document was not available for annotating.

Klar, G., and Young, R. 2004. Integrated management of sea lampreys in the Great Lakes 2004. United States Fish and Wildlife Service, Sea Lamprey Control. 88 p.

This document was not available for annotating.

Klassen, C.N., and Peake, S.J. 2005. An assessment of current rearing methods in hatchery production of lake sturgeon (*Acipenser fulvescens*): do black fly larvae (Diptera: Simuliidae) represent a more efficient feeding regime?, p. 38. *In* 2005 abstracts of oral presentations, Canadian Conference for Fisheries Research and the Society of Canadian Limnologists 2005 meeting, Windsor, Ontario, 6-9 January, 2005. [Abstract only]. Available from www.phys.ocean.dal.ca/ccfrr/ [accessed 4 April 2006].

Knights, B.C., Vallazza, J.M., Zigler, S.J., and Dewey, M.R. 2002. Habitat and movement of lake sturgeon in the upper Mississippi River system, USA. *Trans. Am. Fish. Soc.* **131**: 507-522.

Transmitters were implanted into 31 lake sturgeon in the upper Mississippi River. The areas surrounding the tagging sites were of high use and many tagged sturgeon returned often. Although tagged fish moved upstream and downstream on the Mississippi, dams obstructed upstream passage. This lake sturgeon population shared many movement and habitat use characteristics with populations in other drainage basins.

Koel, T.M., and Peterka, J.J. 1998. Stream fishes of the Red River of the North basin, United States: a comprehensive review. *Can. Field Nat.* **112**: 631-646.

The Red River of the North basin contained 84 species of fish from 19 different families. Of this total, 29 species were cyprinids, and 10 percids, 9 centrarchids, 9 catostomids, and 6 species were ictalurids. Lake sturgeon had not been collected from the basin since the 1950s, but had been reintroduced to the Otter Tail and Pelican Rivers in 1997.

Kohlhorst, D.W., Botsford, L.W., Brennan, J.S., and Cailliet, G.M. 1991. Aspects of the structure and dynamics of an exploited central California population of white sturgeon (*Acipenser transmontanus*), p. 277-293. *In* P. Williot (ed.) *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989, Bordeaux, France.

This document summarized abundance and mortality rate estimates up to 1988, described general movement patterns since 1974, discussed the effects of hydrology on year class strength, and estimated the effect of sport fishing regulations on yield for white sturgeon in central California. Lake sturgeon were not discussed. The authors recommended a change in angling regulations to decrease white sturgeon harvest. Changes being considered included increasing the minimum size limit, imposing a maximum size limit, initiating a "slot limit", and season or area closures.

Konkle, B.R., Ferguson, M.M., and McKinley, S. 1992. Characterization of gene flow and genetic diversity of Moose River lake sturgeon (*Acipenser fulvescens*) populations using radiotelemetry, PCR, and mtDNA sequencing. *In* Report on the Operation of the Clemens-Rigler Travel Fund in Support of Student Attendance at the Canadian Conference for Fisheries Research (CCFFR) and the Conference of the Society of Canadian Limnologists (SCL), Halifax 1992, and Report on the 45th Canadian Conference for Fisheries Research CCFFR 1992. Pagination unknown. [Abstract only].

Koonce, J.F., Busch, W.-D.N., and Czapla, T. 1996. Restoration of Lake Erie: contribution of water quality and natural resource management. *Can. J. Fish. Aquat. Sci.* **53**: 105-112.

Lake sturgeon were listed in Table 1 as being of native origin, spawning in tributaries with a high specificity to spawning sites, being common in abundance pre-1800, and rare at present.. Degradation of spawning and nursery habitat in tributaries and nearshore areas of Lake Erie was cited as contributing to the decline of many native species, including lake sturgeon.

Kooyman, B. 1955. An analysis of data collected in 1953 and 1954 from the sturgeon fisheries on the Nelson River and Churchill River. Manit. Dept. Mines Nat. Res. Game Fish. Br. MS. Rep. 8 p. + figs.

This report offered some historical data and useful insights into the problems of over exploitation of lake sturgeon populations. In 1955, the Nelson River adult sturgeon population was estimated to be 25% of its former strength and unable to sustain the annual harvest of 10,000 pounds. The Churchill River had a much younger population that was also believed to be unable to sustain an annual harvest of 10,000 pounds over the next 10 years. Recommendations included reducing production substantially, increasing the individual size limit to protect the immature fish, and setting the season so as to allow spawning. Continuing the fishery until it collapsed was suggested as a means of collecting population data on the species so that better management strategies could be developed for the future.

Korman, J., and Walters, C. 2001. Nechako River white sturgeon recovery planning: summary of stock assessment and Oct. 2-3, 2000 workshop. Prepared for BC Fisheries, Victoria, BC. v + 26 p.

This workshop reviewed data collected under the Fraser River White Sturgeon Monitoring Program and possible causes for recruitment failure in the Nechako River stock. It also dealt with uncertainties in the development of successful recovery strategies. An age-structured population dynamics model was developed to predict population age structure, track changes in stock size associated with recruitment failure, and predict population recovery rates if conditions for recruitment are re-established. This model was described in detail. Lake sturgeon were not discussed.

Kornberg, J.S., Higginbotham, D.L., and Peterson, D.L. 2004. New method for intensive culture of lake sturgeon using natural and artificial diets. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

In 2002, the Georgia Department of Natural Resources launched a hatchery propagation program for lake sturgeon reintroduction. Initial efforts were hampered by low larval survival, because of poor culture methods. Therefore, several larval diets were tested as part of a 10-year restoration plan. Larvae reared for 5 weeks were studied using 3 different diets with varying amounts of natural and artificial feeds. Frozen preparations containing 1/3 formulated feed resulted in the highest survival rate during the transition to a commercial diet.

Kornely, G.W. 1988. Lake sturgeon creel survey of the Menominee River Wisconsin-Michigan boundary water, 1981-1984. Bur. Fish. Manage. Wis. Dept. Nat. Res., Madison. Fish Manage. Rep. 134: 20 p.

This report described a creel survey of lake sturgeon along the Menominee River. A map outlined the main areas where hook and line fishing was allowed in the watershed, and details of the Menominee River (including location of dams) were given. Lake sturgeon used to migrate from Green Bay up to Sturgeon Falls, but dams now prevent any migration. A creel survey in 1969-70 between White Rapids

and Grand Rapids concluded that exploitation was too high, so the size limit of lake sturgeon was increased from 42 to 50 inches in 1974. A creel survey was done in 1981-82, and mandatory registration was begun in 1983. Fishing pressure was calculated for each category of day (weekday, weekend, opening day) as number of days x 12 hours x average angler count. The harvest was about 20 sturgeon per year in the 1980s, substantially less than 10 years earlier. Anglers who caught a legal sized sturgeon was more likely to return postcards than anglers who did not catch a sturgeon. Mandatory registration, and law enforcement to ensure it, was recommended as a more accurate method of determining harvest.

Kornely, G., and Thuemler, T. 1989. Hook and line lake sturgeon fishery Menominee River, Wisconsin - Michigan. Wis. Dept. Nat. Res. MS. Rep. 12 p.

This study reported the results of the first seven years of a registration system instituted in 1983 on the Menominee River for lake sturgeon fished there. The minimum size limit for lake sturgeon was 50 inches and the bag limit was two fish per season. The season covered the period from the first Saturday of September to November 1. About 66% of the harvest consisted of fish 50-54 inches in length. The length-weight relationship was given by the formula $\text{Log}W = -4.32 + 3.38 \text{ Log}L$, where W is weight in pounds and L is total length in inches. Ninety-one percent of the harvest occurred in September and Wisconsin anglers accounted for 86% of it.

Kowalevsky, A.O. 1871. Sitzungsberichte der zoologischen Abtheilung der III. Versammlung russischer Naturforscher in Kiew. Z. Wiss. Zool. 22: 292.

Professor Kowalevsky presented personal communications from scientists on various topics. Pertinent was the communication by Ph. Owsjannikoff (p. 292) on a new parasite found in the eggs (roe) of the sterlet (*Acipenser ruthenus*). The parasite stolon within the egg, and the changes in the polyps after eggs contacted water were described. Visible polyp structures were also briefly described.

Kowalski, A., and Hill, T. 2004. Status of lake sturgeon in Michigan waters of Lake Huron, reported by commercial fisheries 2003. United States Fish and Wildlife Service, Alpena Fishery

Resources Office, Alpena, MI. 13 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-sagbay03.pdf> [accessed 4 April 2006].

This report detailed the 2003 activities of an ongoing project, started in 1995, to monitor lake sturgeon in Saginaw Bay of Lake Huron. Lake sturgeon caught as by-catch in the commercial fishery were used to collect data. Total length, fork length, and girth were measured. The marginal ray of the left pectoral fin was removed for aging and the distal portion of each fin ray was preserved for genetic analysis. Most lake sturgeon were tagged. Since 1995, 301 lake sturgeon had been tagged. In 2003, 19 lake sturgeon were caught, mostly during the months of April and May. Morphological results were summarized.

Kowalski, A., Zollweg, E., and Hill, T. 2002. Lake sturgeon status survey in Saginaw Bay of Lake Huron as reported by commercial fishers. United States Fish and Wildlife Service, Alpena Fishery Resources Office, Alpena, MI. 15 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-sagbay01.pdf> [accessed 4 April 2006].

This report described the 2001 activities of an ongoing project, started in 1995, to monitor lake sturgeon in Saginaw Bay of Lake Huron. Lake sturgeon caught as by-catch in the commercial fishery were used to collect data. Total length, fork length, and girth were measured. The marginal ray of the left pectoral fin was removed for aging and the distal portion of the fin ray was preserved for genetic analysis. Most lake sturgeon were tagged. Since 1995, 302 lake sturgeon had been caught. In 2001, 69 lake sturgeon were caught, most frequently in the months of May and October. The fork length ranged from 48 to 183 cm, the total length from 53 to 191 cm, and the girth from 15 to 83 cm. Morphological data were summarized.

Kowalski, A., Zollweg, E., and Hill, T. 2003. Status of lake sturgeon in Michigan waters of Lake Huron, reported by commercial fisheries 2002. United States Fish and Wildlife Service, Alpena Fishery Resources Office, Alpena, MI. 9 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-sagbay02.pdf> [accessed 4 April 2006].

Lake sturgeon caught as by-catch in the commercial fishery were used to collect data. Total length, fork length, and girth were measured. The marginal ray of the left pectoral fin was removed for aging and the distal portion of each fin ray was collected for genetic analysis. Most lake sturgeon were tagged. In 2002, 57 lake sturgeon were caught. Morphological data were summarized.

Krieger, J. 1996. Molecular phylogeny of North American acipenseriformes derived from ribosomal RNA gene sequences, p. 95-101. In S. Doroshov, F. Binkowski, T. Thiemler, and D. MacKinlay (ed.) Culture and management of sturgeon and paddlefish symposium proceedings. International Congress on the Biology of Fishes. San Francisco State University, San Francisco, CA, July 14-18, 1996.

This molecular phylogenetic study was conducted to learn about the evolutionary relationships of the extant species of sturgeon and paddlefish. Consensus neighbor-joining trees based on the partial nuclear 18S rRNA gene sequence and the partial mitochondrial 12S rRNA gene sequence were provided. The grouping of some *Acipenser* species appeared to be related to their species range. *A. fulvescens* was clustered with *A. brevirostrum*.

Krieger, J., Fuerst, P.A., and Cavender, T.M. 1997. Molecular phylogeny of North American acipenseriformes based on mitochondrial DNA sequences, p. 561. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Krieger, J., Fuerst, P.A., and Cavender, T.M. 2000. Phylogenetic relationships of the North American sturgeons (order Acipenseriformes) based on mitochondrial DNA sequences. *Mol. Phylogenet. Evol.* 16: 64-72.

Nucleotide sequences of 4 mitochondrial genes (12S rRNA, COII, tRNA^{Phe}, and tRNA^{Asp}) in North American sturgeon and paddlefish were studied to reconstruct a phylogeny. Although gene sequence analysis suggested a basal placement of paddlefish, the position of *Scaphirhynchus* remained uncertain. The two *Acipenser oxyrinchus* subspecies analyzed had very similar sequences, and were basal to the remaining *Acipenser* species examined. A.

transmontanus and *A. medirostris* appeared to be sister taxa, as were *A. fulvescens* and *A. brevirostrum*. Comparisons of these results with other studies were presented.

Krise, W.F., DiLauro, M.N., and Redell, L.A. 1994. Getting started: intensive rearing of larval Atlantic and lake sturgeon for restoration programs, p. 16. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Kroeker, K., and Horne, B. 1993. A fisheries survey of the Long Spruce Forebay 1992. North/South Consultants Inc., Winnipeg, Manitoba. vii + 43 p.

The objectives of this survey were to determine the status of lake sturgeon in a mature lower Nelson River forebay, and to continue monitoring fish populations of an established forebay to determine whether changes were still occurring. Four lake sturgeon were captured. The authors predicted that lake sturgeon populations may be low in the area. The presence of a 9 year old sturgeon suggested that successful spawning may have occurred since impoundment. This was the first lake sturgeon caught that was younger than the forebay itself. The composition and relative abundance of species captured during the survey were similar to the survey conducted in 1989. Mean size of major species had increased and biomass of fish based on catch-per-unit-effort had declined slightly since 1989.

Kroon, E.L. 1984. Identification of bone projectile points fashioned by alteration of the caudal fulcra of sturgeon (*Acipenser fulvescens*). *Mich. Acad.* 17: 97-102.

This article addressed the discovery of two specimens of modified lake sturgeon caudal fulcra projectile points. The osteology of the sturgeon tail and the plausibility of the artifact reportedly fashioned from its bones was discussed. The V-shaped fulcra from the dorsal margin of the caudal fin of sturgeon were described in detail with an accompanying X-ray photograph and drawings of the fulcra. Of the 23 fulcra from the specimen (a 65 pound sturgeon) used by the author, 6 conformed to the shape of the recovered artifacts. Modifications to these fulcra involved shortening the basal prongs and

sharpening the dorsal apex to remove a bulbous node. Both slender and thicker fulcra were used to fashion projectile points. An experiment was conducted to measure the efficacy of these fulcra as arrow heads by mounting them on short hardwood foreshafts and a longer hollow hindshaft made of dry cane reed, all of which were available locally, and firing the arrow with fiberglass (35 pounds) and compound (85 pounds) bows. Results showed that at draw weights up to 85 pounds, this indigenously designed arrow equaled the effectiveness of a modern hunting arrow. Lengths of the excavated fulcra indicated that they came from a lake sturgeon weighing approximately 85 pounds.

Krueger, K.M., Schrouder, K.S., Baker, J.P., Ebener, M.P., and McClain, J.R. 1995. Status of coolwater fishes in 1992, p. 73-85. *In* M. P. Ebener (ed.) The State of Lake Huron in 1992. Gr. Lakes Fish. Comm. Spec. Publ. 95-2. Available from www.glfc.org/pubs/SpecialPubs/Sp95_2.pdf [accessed 4 April 2006].

The fisheries objectives for lake sturgeon were to increase its abundance in the United States, so its threatened status could be removed, and to maintain or rehabilitate Canadian populations. The status of lake sturgeon across North America was summarized. Subsistence and commercial fishing issues and management program initiatives were also discussed.

Kynard, B., and Pugh, D. 2003. Development of fish passage for lake sturgeon. Final Report to the Great Lakes Fishery Trust. S.O. Conte Anadromous Fish Research Center, Leetown Science Center (USGS/BRD), Turner Falls, MA. 45 p.

This document was not available for annotating.

Kynard, B., Pugh, D., Henyey, E., Parker, T., and Horgan, M. 2005. Research on up- and downstream passage of lake sturgeons at S. O. Conte Anadromous Fish Research Center. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 21 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 4 April 2006].

Laberge, M. 1996. Spring subsistence sturgeon harvest of the Eastmain - Opinaca Reservoir. Marc Laberge Consultant, Québec, Canada. 19 p. + apps.

Between July 2nd and 16th, 1996, 54 lake sturgeon with a combined weight of 377 kg were caught in nets set at two sites on the Eastmain River. During the 1995 spring harvest, 110 sturgeon were caught in the Eastmain River in 13 days. The estimated total weight was 770 kg. In 1996, 377 kg of lake sturgeon were harvested. Between July 4th and 8th, 1996, 13 lake sturgeon were caught in nets set on the Little Opinaca River, and a potential spawning ground was found in a tributary of this river. The spring subsistence harvest in the Wemindjii area was estimated at 70-125 lake sturgeon with an estimated combined weight of 990 kg. This harvest occurred over a two week period. Recommendations included informing the fishers of the "fragility" of sturgeon populations, and the establishment of a quota. Total length, weight, sex, stage, and gonad weight of sturgeon caught are summarized in the appendix. Raw data sheets are also included.

LaHaye, M. 1992. Comparaison de la biologie et de l'écologie des jeunes stades de l'esturgeon jaune (*Acipenser fulvescens*) dans les rivières des Prairies et L'Assomption, près de Montréal. Mémoire présenté comme exigence partielle de la Maîtrise en Sciences de l'Environnement, Université du Québec à Montréal. 135 p.

A comparative study on reproduction, embryonic development, larval growth, physical characteristics of spawning habitat, feeding and growth of juvenile lake sturgeon was done between des-Prairies and Assomption rivers near Montréal. The timing of spawning at both sites overlapped in 1989. The similarity in the timing and embryonic development indicated that spawners from both sites were from the same stock. The number of eggs found at sampling stations decreased as depth and water velocity increased at both locations. Substrate used for spawning varied between fine and coarse gravel, and large rocks. Results from experimental gill netting demonstrated that the largest numbers of juvenile lake sturgeon were collected over clay substrates. Stomach content analyses of juveniles indicated that fish from the Assomption River fed on chironomid larvae, crustaceans and amphipods while fish from des-Prairies River fed on amphipods, chironomid

larvae and gastropods. Growth of juveniles between both rivers was similar. Recommendations were made on the creation of artificial spawning grounds and ways to protect spawning and juvenile habitats in the St. Lawrence Seaway.

LaHaye, M. 1996. Scénarios d'aménagement d'une frayère à esturgeon jaune dans le bief d'aval de la centrale Rivière-des-Prairies. Rapport final préliminaire. Report prepared for Hydro-Québec, Direction Maisonneuve by Enviro-science Inc., Montréal, Québec. 22 p.

This document was not available for annotating.

LaHaye, M., and Clermont, S. 1999. Frayère de Beauharnois. Reproduction de l'esturgeon jaune (*Acipenser fulvescens*) près la rive gauche du canal de fruite no 1. Rapport préparé pour la Direction Production, Beauharnois-Gatineau, Hydro-Québec. Enviro-science Inc., Montréal, Québec. vii + 27 p. + apps.

In the beginning of December 1998, Hydro-Québec created lake sturgeon spawning habitat downstream from the Beauharnois generating station on the left bank of tailrace number 1. Prior studies had identified the presence of large mature lake sturgeon in the area although it was not known whether spawning occurred, nor whether spawning fish even used the area. In order to answer both questions, experimental gill netting and the placement of a series of trays with artificial substrates for egg collection took place in 1998. A total of 61 lake sturgeon were captured in the spring of which 1 female was a maturity stage 5, 7 maturity stage 4 males, 1 maturity stage 5 male, and 52 were of undetermined sex. Although results demonstrated the presence of spawning fish, no eggs were found. Past studies had also demonstrated the absence of eggs at the study site. The results indicated that there is a small probability that the site is used by lake sturgeon for spawning.

Lahaye, M., and Fortin, R. 1990. Caractérisation de l'habitat de fraie et de l'habitat des juveniles de l'esturgeon jaune (*Acipenser fulvescens*) dans la région de Montréal. Département des sciences biologiques, Université du Québec à Montréal, Montréal, Québec. ix + 81 p. + apps.

This study had the following objectives: 1) synthesize data from known spawning sites in Québec; 2) quantify parameters from spawning sites in the des-Prairies, Assomption and Ouareau Rivers; and 3) quantify habitat of larval and juvenile lake sturgeon in the lower reaches of the des-Prairies and Assomptions Rivers. A literature review indicated that known spawning sites were located in rapids 0.25-3 m deep, with water velocities ranging from 0.25-1.7 m/s, and substrates of fine, medium and large gravel, and large stones. Driftnets were set to collect larvae and environmental variables were measured at each site. Results suggested that lake sturgeon spawn on heterogeneous substrate consisting of fine and large gravel with large rocks and that depth was not significantly associated with egg quantity. No eggs were found in areas with currents exceeding 2 m/s and homogeneous substrate. Juvenile lake sturgeon between 200 and 1000 mm were captured using gill nets. Their preferred habitat was characterized as margins of holes with clay substrate. It appeared that these habitats were associated with prey items such as chironomid larvae.

LaHaye, M., and Gendron, M. 1994. Reproduction de l'esturgeon jaune, bief d'aval de Pointe-des-Cascades et de Beauharnois. Le Groupe de Recherche SÉEEQ Ltée, rapport réalisé pour Hydro-Québec, vice-présidence Environnement. viii + 73 p. + apps.

A study was done in 1993 to examine lake sturgeon spawning and characterize habitat of a stretch of river downstream from the Beauharnois generating station and the Pointe-des-Cascades reservoir in order to establish a management plan to promote lake sturgeon reproduction. Lake sturgeon were radio tagged and movements followed between May 17 and June 17. Habitat was broadly characterized by current speed, depth and substrate types and a finer description was made at sites with higher concentrations of large, sexually mature fish. A total of 223 fish were captured in the study area. A large spawning run was observed at Beauharnois with the capture of 141 fish of which 12 were mature females and 78 mature males. At Pointe-des-Cascades, 82 fish were captured of which 4 were female and 37 male. The water temperatures were between 10.5 and 12.5°C. The habitat characterization demonstrated unstable flows at Pointe-des-Cascades. Management recommendations to improve lake sturgeon spawning included the

creation of artificial spawning grounds at Beauharnois and Pointe-des-Cascades, and ensuring suitable flows during the spawning season.

LaHaye, M., Branchaud, A., Gendron, M., Verdon, R., and Fortin, R. 1992. Reproduction, early life history, and characteristics of the spawning grounds of the lake sturgeon (*Acipenser fulvescens*) in Des Prairies and L'Assomption Rivers near Montréal, Québec. Can. J. Zool. 70: 1681-1689.

Spawning, early life history, and morphological characteristics of lake sturgeon from Des Prairies River and L'Assomption River were compared. In 1989, spawning in Des Prairies River occurred from May 14 to 27 and in L'Assomption River, from May 15 to 22. The water temperatures were 11.6°C-15.4°C and 11°C-21.5°C, respectively. The embryos in L'Assomption River were larger than in Des Prairies on any given day, and began hatching 3 days earlier. However, sturgeon from these two rivers could not be differentiated based on these biological factors. Larvae emigrated from the Des Prairies spawning grounds on May 29, 11 days after peak spawning. By June they had drifted to the St. Lawrence River and were 20 mm in length. As depth and velocity increased in both rivers, the proportion of stations with eggs decreased. Egg deposition was observed on a wide variety of substrate types, ranging from fine to medium-sized gravel to boulders. In 1990, the artificial spawning bed in Des Prairies River had a high proportion of stations with eggs.

LaHaye, M., Desloges, S., Cote, C., Deer, J., Philips, S.Jr., Giroux, B., Clermont, S., and Dumont, P. 2003. Location of lake sturgeon (*Acipenser fulvescens*) spawning grounds in the upper part of the Lachine Rapids (St. Lawrence River). Study carried out on behalf of the Société de la faune et des parcs du Québec, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Technical Report 16-15E: ix + 43 p.

The objectives of this study were to confirm lake sturgeon egg deposition in the study area, to determine the area in which lake sturgeon spawn, to compare results with those from other spawning grounds, and to develop a new method for sturgeon egg sampling. Cement parpens covered with air filter material, and dip and drift nets were used to sample sturgeon

eggs and larvae. The parpens were placed on the riverbed in previously identified sections. Due to the sticky nature of fresh sturgeon eggs they clung to the air filter material covering the parpens. Sectors were chosen based on depth, substrate, current speed, and the presence or absence of vegetation. Lake sturgeon eggs were found in two sectors of the study area. Thirty-five eggs and 4 larvae were sampled using parpens at 11 stations on June 3 and 11, 2002. The spawning area had a depth range of 1.5 to 3.0 m, with an average near 2 m. The current speed was faster at the surface than at increasing depths, declining from an average of 1.6 to 1.31 m/s. The flow rate was between 1.02 and 1.91 m/s. The substrate appeared to consist of boulders, rocks and gravel. Large boulders were found on the upstream edge of the spawning zone and some directly on it. The substrate appeared to be void of vegetation. Other species for which eggs were collected include redbhorse (*Moxostoma* sp.), mooneye (*Hiodon tergisus*) and darters (*Etheostoma* sp.). The results confirmed that lake sturgeon harvesting should not take place during the spring.

LaHaye, M., Desloges, S., Cote, C., Rice, A., Phillips, S.Jr., Deer, J., Giroux, B., de Clerk, K., and Dumont, P. 2004. Search for and characterization of lake sturgeon (*Acipenser fulvescens*) spawning grounds in the upstream portion of the Lachine Rapids, St. Lawrence River, in 2003. Study carried out on behalf of the [Québec] Ministère des Ressources naturelles, de la Faune et des Parcs, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Technical Report 16-20E: ix + 48 p.

The objectives of this study were to check the use of the spawning grounds discovered in 2002 by extending the coverage up to 7 m in depth (from 5 m in 2002 study), to determine the boundaries of the spawning area with greater accuracy, to compare the environmental characteristics of the sectors sampled and/or used for spawning, and to compare the results with those from 2002 and previous studies. Sampling methods were the same as those used in 2002 (La Haye *et al.*, 2003) with the addition of an underwater camera used to determine substrate. Lake sturgeon eggs were only found in the study area identified in 2002. A total of 163 eggs were harvested with parpens between May 23rd and June 16th. The majority of eggs were collected between May 23rd and 27th.

A total of 103 eggs were caught with drift nets placed downstream of the spawning grounds between June 6th and 19th. The spawning zone used was 2.3 ha in 2002 and 3.6 ha in 2003. The potential spawning zone had an area of 2.4 ha, giving a total of 6 ha for 2003. Spawning occurred under rapid flow conditions from the centre towards the edge of the spawning ground. The substrate consisted of rocks and big rocks with fine to coarse gravel. A lack of aquatic vegetation at the time of spawning was noted. Other species for which eggs were collected include redbhorse (*Moxostoma* sp.), mooneye (*Hiodon tergisus*), walleye (*Stizostedion* sp.) and Percidae. These results further confirmed the need to stop all forms of lake sturgeon harvesting in the Lachine Rapids in spring.

Lake Michigan Lake Sturgeon Task Group. 2003. Lake Michigan lake sturgeon rehabilitation plan (draft). United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 17 p.

This document was not available for annotating.

Lamb, N. 1984. Lake sturgeon - on the way back. *MO. Conserv.* 45: 4-7.

This article provided a general description of lake sturgeon biology. Efforts to restore lake sturgeon in Missouri through artificial propagation were also discussed.

Lambert, Y., and Dodson, J. 1982a. Composition, distribution et abondance de l'ichthyofaune adulte de l'estuaire de la rivière Eastmain (Baie James). Programme de recherche sur l'estuaire de la rivière Eastmain (Baie James). GIROQ (Groupe Interuniversitaire de Recherches Océanographiques du Québec), rapport à la SEBJ (Société d'Énergie de la Baie James), Montréal, QC. 88 p.

This document was not available for annotating.

Lambert, Y., and Dodson, J. 1982b. Structure et rôle des facteurs physiques dans le maintien des communautés estuariennes de poissons de la baie James. *Nat. Can. (Qué.)* 109: 815-823.

During the spring, summer and fall of 1979, the estuary of the Eastmain River at James Bay, Québec was studied. Multivariate analyses were

used to divide the study area into seven physical groups based primarily on temperature and salinity. Discriminant analyses showed that the physical groups were characterized by eight fish species and could be separated based on densities of these fish. In general, 48.8% of fish samples were classified in the correct physical group. Most of the correct classifications occurred when migratory movements and reproduction were at a minimum. The authors concluded that the Eastmain fish community structure could only be partially explained by the physical regime.

Lamontagne, D., and Gilbert, L. 1990. Étude des frayères du Saint-Maurice en aval de la centrale de La Gabelle, 1990. G.D.G. Environnement ltée, pour la Vice-présidence Environnement, Hydro-Québec, Montréal, Québec. xvii + 111 p. + apps.

This study was completed prior to renovating the La Gabelle generating station to characterize walleye, white sucker, longnose sucker and lake sturgeon spawning, collect data on water quality, evaluate potential impacts from the construction work on reproduction, migration, spawning, and egg incubation and hatching. A total of 1,016 fish were captured, including 511 longnose sucker, 152 walleye, 146 white sucker and 128 lake sturgeon. The peak spawning period for these species was between May 9 and 24, 1990, when water temperatures ranged from 8.3-11.5°C. Eggs hatched in June. A lake sturgeon spawning site was located 125 m from the dam on a substrate consisting of boulders with gravel among the interstitial spaces. The construction of temporary bulkheads and a bridge will increase the turbidity of the water. The impact on lake sturgeon and walleye spawning was deemed to be intermediate, while it was minor for the longnose and white sucker.

Lamoureux, P., and LaForge, G. 1991. Analyse des captures et caractéristiques biologiques de l'esturgeon jaune (*Acipenser fulvescens*) dans le couloir fluvial du Saint-Laurent de 1985 à 1989, p. 315-326. In P. Williot (ed.) *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989. Bordeaux, France.

Lake sturgeon commercial fishery data from 1986 and 1988 were analyzed for the

Contrecoeur Trois-Rivières portion of the St. Lawrence River. Potential causes for changes in small sturgeon abundances and variations in mortality rates were discussed.

LaPan, S.R., Klindt, R.M., Johnson, J.H., and Schiavone, A. 2000. Lake sturgeon spawning on artificial habitat in the St. Lawrence River, p. 7. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 4 April 2006].

LaPan, S.R., Klindt, R.M., Schiavone, A., and Johnson, J.H. 1997. Lake sturgeon spawning on artificial habitat in the St. Lawrence River, p. 460. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

LaPan, S.R., Schiavone, A., Klindt, R.M., and Colesante, R.T. 1997. 1997 lake sturgeon restoration activities. Section 16, p. 1-4. In NYSDEC (New York State Department of Environmental Conservation) Lake Ontario Annual Report 1997 (St. Lawrence River Unit). Available from <http://www.dec.state.ny.us/website/dfwmr/fish/sturg97.pdf> [accessed 4 April 2006].

This document provided an update on the status of a lake sturgeon restoration program in New York. The goal of the project was to re-establish a self-sustaining lake sturgeon population in the St. Lawrence River and its tributaries. Methods used included enhancement/creation of spawning habitat and/or stocking. In October of 1997, 2,937 lake sturgeon fingerlings were stocked at three locations on the Oswegatchie River and 250 fingerlings each were stocked into the St. Lawrence River at Ogdensburg and Massena. The results of previous habitat enhancement activities were reported.

LaPatra, S.E., Ireland, S.C., Groff, J.M., Clemens, K.M., and Siple, J.T. 1999. Adaptive disease management strategies for the endangered population of Kootenai River white sturgeon. *Fisheries* 24: 6-13.

A case study on control of introduced diseases in white sturgeon culture was presented. The most prevalent disease in cultured white sturgeon is the white sturgeon iridovirus (WSIV). This virus attacks the epithelial tissue of the skin and gills and may cause >90% mortality. Juveniles, younger than the age of 1, are most severely impacted. Strategies used to control WSIV include lowering fish culture density and loading, use of virus-free water, decreasing adverse environmental conditions, and minimizing handling of sturgeon below the age of 1. The Kootenai River white sturgeon conservation aquaculture and stocking programs were discussed in relation to disease management.

Larson, T. 1988. The lake sturgeon fishery of Lake Wisconsin, 1978-1985. Bur. Fish. Manage. Wis. Dept. Nat. Res. Fish. Manage. Rep. **136**: 34 p.

This study examined angler fishing pressure on Lake Wisconsin sturgeon, and estimated the population and harvest yields. Angling characteristics for 1979 included a predominance of male anglers (94%) with 92.8% of the anglers being between the ages of 16-65. Estimates of the total population ranged from 8,000-23,000 depending on the methods used. The Peterson and multiple-recapture methods were compared and discussed with respect to sampling bias. The average rate of recruitment for 1979-81 was 23%. Over the years 1983 to 1985, the annual harvest between the Prairie du Sac and Wisconsin Dells dams was 73 sturgeon, and the exploitation rate was estimated at 7.3%. The length-weight relationship was given by $\log L = -4.319 + 3.398 \log W$, where L is length in inches and W is weight in pounds. The age-length equation was $l_t = 64.31(1 - e^{-0.0887(t+1.652)})$, where l_t is the length at age t . Analysis of movement showed that lake sturgeon moved randomly throughout the lake area. Sturgeon spawned in 50-51°F water and recaptures indicated a 30-40 mile spawning migration to and from the Wisconsin Dells dam. Five fish >50 inches showed metal and pesticide levels well below detection levels. Three sturgeon had PCB levels at or above the 2.0 ppm FDA tolerance level. Management recommendations included continued voluntary angler surveys and mandatory registration to assess catch and harvest, a reduced annual harvest limit of 50 fish, promoting trophy sturgeon fishing, monitoring for PCB levels,

enhancing spawning sites, and conducting a life history study to determine habitat characteristics for fingerling and yearling sturgeon.

Lathrop, R.C., Nehls, S.B., Brynildson, C.L., and Plass, K.R. 1992. The fishery of the Yahara Lakes. Wis. Dept. Nat. Res. Tech. Bull. **181**: Pagination unknown.

This report presented published and unpublished data collected from the late 1800s to 1985 in the four Yahara River lakes. Major data sources included creel surveys, rough fish removal records, fish population surveys, stocking records, fish distribution surveys, and research projects. Information regarding morphometric characteristics, water temperature, dissolved oxygen, lake fertility, toxics, macrophytes, invertebrate food organisms, wetlands, and water level fluctuations were also collected. The ecological requirements of 17 fish species were discussed and the rarity of lake sturgeon in this area was noted. Impacts on the fishery in these lakes and recommendations for improvement were discussed.

Lauer, C. 1988. Identification of critical life history periods of lake sturgeon and factors that may affect population survival. Correspondence/Memo to Ontario Ministry of Natural Resources, Kapuskasing District Manager, Kapuskasing, ON. 9 p.

In this correspondence, the author examined the potential effects of hydroelectric installations on lake sturgeon populations. Inferences were made from comparable studies carried out on Eurasian sturgeon. Direct impacts included fluctuating levels caused by controlled dam discharges, and the blockage of migratory routes. Critical periods such as overwintering, pre-spawning, spawning, and egg hatching were adversely affected by fluctuating water levels and water flow rates, and consequently by fluctuating temperatures. The importance of water current on spawning migration, spawning acts and downstream larval drift was discussed. Other environmental factors considered included low oxygen tensions coupled with increased temperature, nature of the substrate and prey community structure, water depths, and turbidity.

Laufle, J.C., Anders, P., Marcuson, P., Westerhof, R., and Shaar, D. 1994. Cooperative efforts to recover Kootenai River white sturgeon, p. 4-5. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Lawrie, A.H., and Rahrer, J.F. 1972. Lake Superior: effects of exploitation and introductions on the salmonid community. *J. Fish. Res. Board Can.* **29**: 765-776.

This paper identified the effects of industrial pollution, exploitation and introduction of exotic fish species on native fish populations of Lake Superior. While the focus was on the coregonids and salmonids, lake sturgeon were also mentioned. The lake sturgeon was one of few fish species that had yielded harvests of over 200,000 pounds. The maximum harvest occurred during the first recorded season in 1885, when 224,000 pounds were taken. Production declined at an average rate of 9% per annum until 1920, after which harvests exceeded 10,000 pounds only three times. The inability of lake sturgeon to withstand high fishing pressures was attributed to its low biotic potential. Habitat destruction by discharges from the lumber industry also contributed to the collapse of this fishery.

Lawrie, A.H., and Rahrer, J.F. 1973. p. 54-55. *In* Lake Superior: a case history of the lake and its fisheries. *Gr. Lakes Fish. Comm. Tech. Rep.* **19**. Available from www.glfc.org/pubs/TechReports/Tr19.pdf [accessed 4 April 2006].

Contemporary knowledge and historical aspects of fish stocks in Lake Superior were summarized. A long period of overfishing and sea lamprey predation were identified as causes of decline in many fish populations. The effects were deemed to be partially reversible by controlling sea lamprey populations and stocking from hatcheries.

Lawson, K. 1983. Biology, age, growth and angler harvest of lake sturgeon (*Acipenser fulvescens*) of the Groundhog and Mattagami Rivers, 1982. Ontario Ministry of Natural Resources, Kapuskasing District MS. Rep. 49 p.

This document was not available for annotating.

Leach, J.H., and Nepszy, S.J. 1976. The fish community in Lake Erie. *J. Fish. Res. Board Can.* **33**: 622-638.

The fish community of Lake Erie was discussed in relation to historic environmental changes and the effects of commercial fishing. A number of fishes, including the lake sturgeon, had virtually disappeared due to over-fishing and pollution. The draining and filling of bordering marshland was believed to have reduced spawning areas of species such as lake sturgeon. The environmental changes including changes in fishing methods were reviewed, and historical accounts were provided of the more important fishery species including the lake sturgeon. This species, considered abundant during the late 1800's was first fished out and dumped, and later commercially exploited to near extinction. The alteration of habitat also contributed to the decline in native sturgeon populations.

Lebreton, G.T.O. 1999. Lake sturgeon growth chronologies. Ph.D. Thesis, University of Guelph, Guelph, Ontario. ix + 181 p. Available from www.collectionscanada.ca/thesescanada/index-e.html [accessed 4 April 2006].

This thesis examined whether lake sturgeon growth rings meet the criteria needed to develop growth chronologies. The width of the growth rings must be related to somatic growth of the individual, the synchrony of the interannual growth variations should match growth chronology, and the growth rings and related chronologies should show evidence of the influence of large scale external factors (ex. temperature). Lake sturgeon growth rings met all of these criteria. They were negatively correlated with tree growth. Annual changes in sturgeon growth were then successfully modeled in two populations using historic records of environmental and tree growth variation.

LeBreton, G.T.O., and Beamish, F.W.H. 1998. The influence of salinity on ionic concentrations and osmolality of blood serum in lake sturgeon, *Acipenser fulvescens*. *Environ. Biol. Fishes* **52**: 477-482.

This study examined the ability of lake sturgeon to tolerate saline conditions. Twenty juvenile lake sturgeon were taken from the Moose River and slowly transferred to increasingly saline

conditions at a rate of 2‰ per day. Blood was taken from fish after a 48 hour acclimation period at intervals of 0, 10, 15, and 25‰ salinity concentrations. Poor health and two mortalities were observed at the 25‰ concentration, so the experiment was terminated. Concentrations of Na^+ , K^+ , Cl^- , Ca^{2+} and osmolarity were measured at each interval. In freshwater conditions, lake sturgeon blood serum displayed comparable osmotic and ionic composition to other North American sturgeon. Lake sturgeon were not capable of homeostasis above 15‰. Larger fish seemed to have a greater tolerance to higher salinities.

LeBreton, G.T.O., and Beamish, F.W.H. 2000a. Interannual growth in fish and tree rings. *Can. J. Fish. Aquat. Sci.* **57**: 2345-2356.

Interannual variations were compared among adjacent populations of lake sturgeon, white spruce, white pine, and red pine. Long-term growth trends were removed from ring-widths in the hard tissues of aquatic and terrestrial organisms and were assembled into chronologies. Interannual growth variations were negatively correlated between sturgeon and tree chronologies for those fish that showed strong interseries correlation. The three sturgeon chronologies that had little interseries correlation had no relationship to tree growth. Negative relationships between fish and tree growth may have been related to annual fluctuations in air temperature.

LeBreton, G.T.O., and Beamish, F.W.H. 2000b. Suitability of lake sturgeon growth rings in chronology development. *Trans. Am. Fish. Soc.* **129**: 1018-1030.

This paper assessed the ring widths of pectoral fins rays in relation to the development of growth chronologies. Fin ray rings and growth chronologies could be related to both interpopulation and interannual dynamics of known environmental variables. Somatic growth was documented in annual ring widths. Average fin ray radii at age 25 showed a relationship to total length. Differences between populations in fin ray radii at age 25 were strongly correlated with mean annual, summer, and winter air temperatures. In addition, growth chronologies that were developed from populations that demonstrated synchrony of interannual growth variations were consistently positively correlated

to past air temperature records. These results showed that lake sturgeon pectoral fin rays can be used to develop growth chronologies.

LeBreton, G.T.O., Beamish, F.W.H., and Wallace, R.G. 1999. Lake sturgeon (*Acipenser fulvescens*) growth chronologies. *Can. J. Fish. Aquat. Sci.* **56**: 1752-1756.

Growth synchrony was determined using the pectoral fin rays of lake sturgeon. Decision criteria were based on correlations among individual chronologies built from samples collected in the Saskatchewan River, Lake St. Clair, and the Mattagami River. Interannual growth variation in lake sturgeon was influenced by extrinsic factors in some populations. Growth synchrony and aging error should be quantified during the development of chronologies from all organisms.

Leclerc, P. 1987. Commentaires d'ichtyologistes sur une étude de faisabilité portant sur l'exploitation commerciale de l'esturgeon jaune (*Acipenser fulvescens*) de la rivière Rupert. Ministry of Recreation, Hunting and Fishing, Nouveau-Québec Regional Directorate; Grand Council of the Cree, Québec, QC. Pagination unknown.

This document was not available for annotating.

Lee, D.S., Gilbert, C.R., Hocutt, C.H., Jenkins, R.E., McAllister, D.E., and Stauffer, J.R. , Jr. 1980. *Acipenser fulvescens* Rafinesque, Lake sturgeon, p. 39. In *Atlas of North American Freshwater Fishes*. North Carolina Biological Survey Publication No. 1980-12.

A one page account of the lake sturgeon was provided with short sections on type locality, systematics, distribution, and biology. A map of its distribution was included.

LeJeune, R., and Faucher, J. 1972. Liste préliminaire des poissons d'eau douce de la Radissonie Orientale. *Nat. Can. (Qué.)* **99**: 359-365.

Seven rivers on the coast of James Bay were surveyed for fish in 1967. Fourteen species were found in the foot waters of the Nottaway, Broadback, Rupert, Pontax, Eastmain, Grand Baleine rivers. Results were compared with those from the higher parts of the rivers, showing ecological differences between the

head and foot waters of the same river. There were few differences among estuaries which suggested past and possible present exchanges between watersheds through Rupert's Bay and James Bay.

Lelek, A. 1989. Threatened fishes of Europe. AULA - Verlag, Wiesbaden. 322 p.

Data on the status of acipenserids in Europe were presented in this volume of the series edited by the European Committee for the conservation of nature and natural resources-Council of Europe.

Lenz, C.B. 1970. Sturgeon challenges Wisconsin spearmen. Then and now. State Hist. Soc. Wis. Publ. 16: 2-3.

Spearing sturgeon in Wisconsin waters has not changed much from the days of the Menominee and Chippewa (Ojibway [Ojibwe, Ojibwa]). In the early days sturgeon were speared during spawning in the rivers, and from canoes at night by torchlight. Sturgeon were also speared through the ice by using a weighted wooden decoy fish. Today one needs a spearing license as well as a valid hook and line fishing license. Tags are furnished with each license and must be locked to the tail of the sturgeon. Types of fishing equipment and costs were outlined.

LeSueur, C.A. 1818. Description of several species of chondropterygious fishes. Trans. Am. Philos. Soc. 1: 388-394.

The lake sturgeon was described in considerable detail as a new species, *Acipenser rubicundus*. The type specimen was four feet long and Lake Erie and Lake Ontario were the type localities. Two other varieties were described, one from the lakes mentioned above and the other from the Ohio River. The author mentioned that it was eaten by the Indians but not widely sought after for the table. The paper also contained descriptions of *A. brevirostrum* and *A. maculosus*. *A. maculosus* was subsequently synonymized with *A. rubicundus* by Kirsch and Fordice (1889, see in this bibliography). LeSueur did not mention Rafinesque's brief description of lake sturgeon, or its naming as *Acipenser fulvescens* only one year earlier (Rafinesque, 1817).

Lindberg, G.V., and Legeza, M.I. 1965. Order Acipenseriformes, p. 30-34. In Fishes of the Sea

of Japan and the adjacent areas of the Sea of Okhotsk and the Yellow Sea. Academy of Sciences, Moscow, USSR. [Translated from Russian by M. Raveh, 1969. Israel Program for Scientific Translations, Jerusalem].

Three species of *Acipenser* were discussed, *A. multiscutatus*, *A. medirostris mikadoi*, and *A. kikuchii*, and a key was provided for them.

Linton, E. 1901. Parasites of fishes of the Woods Hole region. Bull. US Fish Comm. 19: 405-492.

Echinorhynchus globulosus Rudolphi and *Distomum auriculatum* were listed as parasites of *Acipenser fulvescens*.

Linton, E. 1989. Notes on the trematode parasites of fishes. Proc. U.S. Natl. Mus. 20: 507-548.

Distomum auriculatum from lake sturgeon was reported for the first time and briefly described.

Lipin, A.N. 1908. Brief outline of the morphologic and histologic structure of the freshwater form of Coelenterata, *Polypodium hydriforme*. Appendix to the protocol of the meeting of the Society of Natural Scientists of Kazan University, No. 245. Pagination unknown.

This document was cited in Raikova (1961b) and was not available for annotating.

Lipin, A.N. 1909. Über den Bau des Susswasserpolyphen *Polypodium hydriforme* Uss. Vorlaufenden Mitteilungen. Zool. Anz. 34: 11-12.

This article was not available for annotating.

Lipin, A.N. 1910. To the biology of *Polypodium hydriforme* Uss. Tr. Obshch. Estest. Khazan. Univ. 42: 5-23.

This article was not available for annotating.

Lipin, A.N. 1911a. Die Morphologie und Biologie von *Polypodium hydriforme* Uss. Zool. Jahrb. Abt. Anat. 31: 317-426.

The life cycle of *Polypodium hydriforme* was described. The parasitic stage was the coiled

stolon within the eggs of the Volga sturgeon, with the germ layers everted so that the endodermis was in contact with the yolk, which surrounded the stolon within the egg. The stolon developed buds along its length and the buds became immature polyps and developed tentacles. During spawning, the basal portion of the stolon split and the entire structure everted so that the germ layers assumed their normal position with the ectodermis facing the outside. During this eversion, a mass yolk became trapped within the basal part of each polyp which supplied the polyp with nutrition in the free living stage. Each polyp had twelve tentacles, made up of two types, with which it moved around on the river bottom. The tentacles increased in number to twenty-four, after which the polyp divided to give rise to two individuals with twelve tentacles.

Lipin, A.N. 1911b. On the life cycle of *Polypodium hydriforme* Uss. Khazani Prot. Obshch. Estest. **42 Beilage (1-6)**: Pagination unknown.

This article was not available for annotating.

Lipin, A.N. 1911c. Über ein neues Entwicklungsstadium von *Polypodium hydriforme* Uss. Zool. Anz. **37**: 97-99.

Previously unreported stages in the development of *Polypodium* were discussed. Two specimens were recovered from infected sterlet eggs. The two infected eggs were larger than normal ones. The parasites appeared as irregular masses with one specimen slightly longer than the other. The cells of the ectoderm and endoderm were described.

Lipin, A.N. 1915. The sexually mature form, the phylogeny, and the systematic position of *Polypodium hydriforme* Ussov 1885. Tr. Obshch. Estest. Khazan. Univ. **47**: 1-145.

This article was not available for annotating.

Lipin, A.N. 1922. On the problem of the number and the position of gonads in *Polypodium hydriforme* Uss. Russ. Hydrbiol. Zeitschr. **1**: 41-43, 91-96.

The ovaries of the twelve tentacled polyp of *Polypodium hydriforme* were originally reported (in 1915, same author) as being eight in number, arranged in four groups of two. Material

examined from the sterlet eggs showed that there were actually two gonads with two ovaries in each, giving a total of four ovaries per polyp.

Lipin, A.N. 1926. Geschlechtliche form, phylogenie und systematische Stellung von *Polypodium hydriforme* Uss. Zool. Jahrb. Jena Abt. Anat. **47**: 541-635.

Free living forms of the coelenterate parasite of sturgeons, *Polypodium hydriforme*, were described with detailed consideration of the different organ systems. Detailed comparisons were made between *Polypodium* and *Paraphyllina* and *Nausithoe*. The phylogenetic position of *Polypodium* within the coelenterates was discussed. It was argued that *Polypodium* was a reduced form of the Coronatae among the Scyphomedusae.

Logan, S.H., and Shigekawa, K. 1986. Commercial production of sturgeon: the economic dimensions of size and product mix. Giannini Research Report **335**: ii + 68 p.

This document provided an economic analysis of commercial sturgeon production as it relates to the artificial propagation and intensive culture of white sturgeon. A systems model was developed to evaluate cost, profit, and rate of return. The results of three simulation experiments, namely, economics of size, alternative marketing strategies, and economics of size and product mix were presented and discussed.

Longmore, L.A., and Stenton, C.E. 1981. The fish and fisheries of the South Saskatchewan River Basin: their status and environmental requirements. Prepared for Alberta Environment, Planning Division, Edmonton, AB. xxii + 335 p.

The six objectives of this report were to: (1) identify fish populations and habitat requirements in the Red Deer, Bow, Oldman, and South Saskatchewan River systems; (2) recommend minimum water discharges to maintain levels of fish production; (3) establish water quality parameters and criteria; (4) describe the recreational and commercial fishery in the area; (5) describe the local sport fishery; and (6) identify any data gaps. This was accomplished by conducting an extensive review of the literature. Lake sturgeon occurred in the South Saskatchewan River and were suspected in the lower Bow and Oldman rivers.

The report divided the study area into sub-basins and further divided the sub-basins into sections. The sub-basins and number of associated sections were as follows: the Red Deer River sub-basin (4 sections), the Oldman River sub-basin (3 sections), the Bow River sub-basin (5 sections), and the South Saskatchewan River sub-basin (1 section).

Loos, A. 1902. Über neue und bekannte Trematoden aus Seeschildkroten. Zool. Jahrb. Abt. Syst. Oekol. Geogr. Tiere **16**: 411-899, 32 pl.

A trematode from the intestine of a lake sturgeon was briefly described under the name *Distomum petalosum* C.H. Lander. This species was considered to be the same as "*Distomum auriculatum* Wedl" described by Linton, but different from the true *D. auriculatum* Wedl.

Lord, J. 1984. The kids ate caviar. The story of Manitoba's mighty sturgeon.....then and now. Nat. Can. (Ott.) **13**: 19-22.

This informal account told the history of sturgeon in Manitoba. Prewar days, when sturgeon and sturgeon poaching were relatively common were discussed. The making of caviar from lake sturgeon roe, and the rich taste of sturgeon flesh were also described.

Love, G.F. 1972. The lake sturgeon (*Acipenser fulvescens*) of Lake Nipissing - 1971 study. Ontario Ministry of Natural Resources MS. Rep. 16 p. + app.

A total of 133 sturgeon were sampled during the 1971 season of which 132 were legal size (25 inches). The average length was 53.7 inches and the average weight (from 116 fish) was 37.1 pounds. Females (n=92) had an average age of 23.3 years (range: 12-51 years) and males (n=34), 21.3 years (range: 11-51 years). A dressed sturgeon lost approximately 33.4% of its whole weight. The male to female ratio was 1:3 and 41 (31.1%) of the legal sized fish had never spawned. The last narrow annulus in each belt of narrow annuli denoted a spawning year. Males first spawned between 10 and 20 years (average 14.8 years) and females between 12 and 22 years (average 16.5 years). Female sturgeon were said to spawn every 6 years. Spawning sturgeon were reported from May 27 - June 15, 1972 below the Sturgeon Falls Dam. It was hypothesized that fish in strong year

classes matured and entered the fishery together so as to produce a sizeable spawning population and a good harvest year. Of the 22 stomachs examined for food items, 10 had only crayfish, 7 had aquatic vegetation and 5 had a variety of items, including mayfly larvae and numerous small perch and unidentified worms. It was recommended that the legal size limit be raised from 25 inches to 30 inches to enable females to spawn once before harvesting.

Lower Great Lakes Fishery Resources Office. 1994a. Sturgeon News **April/May, 1994**: 9 p. [Amherst, NY].

This issue briefly summarized activities of the Lower Great Lakes Fishery Resources Office and included a list of contact information for all subscribers.

Lower Great Lakes Fishery Resources Office. 1994b. Sturgeon News **January, 1994**: 9 p. [Amherst, NY].

This and subsequent bulletins summarized the activities of the Lower Great Lakes Fisheries Resources Office (LGLFRO). It also provided a directory of researchers involved in sturgeon studies.

Lower Great Lakes Fishery Resources Office. 1996. Sturgeon News **November, 1996**: 6 p. [Amherst, NY].

This issue summarized research activities in Lake Erie, Lake Ontario, the St. Lawrence River, Lake Superior, Lake Michigan, Lake Huron, Lake St. Clair, the Wolf River, the upper Fox River and Lake Winnebago.

Lower Great Lakes Fishery Resources Office. 1997. Sturgeon News **November, 1997**: 5 p. [Amherst, NY].

Research activities were summarized for Lake Erie, Lake Ontario, the St. Lawrence River, Lake Huron, Lake St. Clair, the St. Clair River, and Lake Winnebago.

Lowie, C. 1999a. Great Lakes lake sturgeon genetics status assessment: an analysis of samples, methods, and standardization. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **99-02**: 11 p. Available from

<http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 4 April 2006].

This report identified the lake sturgeon activities and composition of genetic samples of each agency associated with lake sturgeon in the Great Lakes. These agencies include: Ashland Fishery Resources Office (Lake Superior), Green Bay Fishery Resources Office (Lake Michigan), La Crosse Fishery Resources Office (Lake Michigan), Alpena Fishery Resources Office (Lake Huron, Lake St. Clair and Western Lake Erie), Lower Great Lakes Fishery Resources Office (Eastern Lake Erie, Lake Ontario and Upper St. Lawrence River), Lake Champlain Fish and Wildlife Resources Office (Lower St. Lawrence River and Lake Champlain), and Law Enforcement - Ashland, Oregon. Standardization and increased interagency coordination were recommended to improve efficiency.

Lowie, C. (program coordinator). 1999b. 1998 summary report of Niagara River and Oswegatchie River research projects. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administration Report **99-01**: 16 p. Available from http://www.fws.gov/midwest/sturgeon/lowergl_page.htm [accessed 4 April 2006].

The objectives of the Niagara River project were to study the distribution, movements, and habitat use of adult and juvenile lake sturgeon, examine the age and growth of juveniles and adults, and to determine the genetic discreteness of the Niagara River population. A total of 7 lake sturgeon were captured in 1998, and 6 of these were tagged. Movements and habitat use were discussed. The purpose of the Oswegatchie River project was to examine the distribution, movements and habitat use of stocked lake sturgeon to measure the success of restoration efforts. A total of 362 lake sturgeon were caught. One was native and from the 1986 year class, the remainder were stocked and from the 1994 to 1997 year classes. An analysis of stomach contents revealed the major food items to be Dipterans, Ephemeropterans, and Trichopterans. Movements were discussed.

Lowie, C. 2000a. Great Lakes lake sturgeon genetics status assessment, p. 7. *In* C. Lowie (ed.) Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization. Holiday Inn - Chicago City

Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **2000-01**. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 4 April 2006].

Lowie, C. (ed.) 2000b. Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs and standardization. Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Great Lakes Fishery Trust and Michigan Department of Natural Resources. Administrative Report **2000-01**: 24 p. Available from <http://www.fws.gov/midwest/sturgeon/Genworkpro.htm> [accessed 4 April 2006].

This workshop proceedings contained 9 abstracts and a summary of the meeting. Abstract titles included: Great Lakes Lake Sturgeon Genetics Status Assessment; Why Genetic Information is Important and How it Can be Used: General Background with Relevance to Sturgeon Conservation and Management; Genetic Considerations for Captive Breeding Programs to Preserve Genetic Variability; Conservation Genetics of Lake Sturgeon in Central Canada; Analysis of Lake Sturgeon Population Structure with Microsatellite Data; Molecular Genetic Characterization of Spatial Population Structure of Remnant Lake Sturgeon Populations in the Upper Great Lakes Basin; Preliminary Results from Genetic Studies of Population Structure in the Lake Sturgeon of the Great Lakes; Identification and Conservation of Genetic Diversity in Atlantic Sturgeon; and Microinjection as a Means of Developing a Molecularly Tagged Stock of Lake Sturgeon.

Lowie, C. (program coordinator). 2000c. Great Lakes native fish restoration: lake sturgeon. FY1997 fisheries stewardship proposal. Final progress report. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office. 21 p. Available from <http://www.fws.gov/midwest/sturgeon/lowie99.html> [accessed 4 April 2006].

This report summarized work completed by the Lower Great Lakes Fishery Resources Office Lake Sturgeon Program in 1999 and early 2000. Included was a summary of the Great Lakes Lake Sturgeon Genetics Workshop, an update

on a project assessing the population of lake sturgeon in the lower Niagara River, an update on a project examining habitat suitability and use of lake sturgeon in the Genesee River, and an update on the Oswegatchie River project in which distribution, movements and habitat of stocked lake sturgeon are being studied. The lake sturgeon sighting program and other public education efforts were described.

Lowie, C., and Hughes, T. 2000. USFWS lake sturgeon program summary, p. 4-6. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 4 April 2006].

Ludwig, A., Belfiore, N.M., Pitra, C., Svirsky, V., and Jenneckens, I. 2001. Genome duplication events and functional reduction of ploidy levels in sturgeon (*Acipenser*, *Huso* and *Scaphirhynchus*). *Genetics* **158**: 1203-1215.

Ploidy levels of 20 sturgeon species were investigated using microsatellite markers. Lake sturgeon had a chromosome number of 250 (inferred from DNA content). Five lake sturgeon microsatellite loci were analysed. These were Afu-19 (ploidy level: 2n), Afu-39 (4n), Afu-54 (4n), Afu-57 (8n), and Afu-68 (4n). The inferred ploidy level for lake sturgeon is 4n. The authors found that several independent genome duplication events occurred during sturgeon evolution. They proposed that the closest ancestor to acipenserids was diploid, with ~120 chromosomes, and that species with higher chromosome numbers resulted from more recent genome duplication events. Gene silencing, chromosomal rearrangements, and transposition events were considered important processes in acipenseriform genome formation. An oceanic subdivision in the *Acipenser/Huso* complex is also discussed.

Lyons, J., and Kempinger, J.J. 1992. Movements of adult lake sturgeon in the Lake Winnebago system. Wis. Dept. Nat. Res. Research Report **156**: 17 p.

Analysis of data from a lake sturgeon tagging program in the Lake Winnebago system from 1952 to 1984, found little intermixing between

fish from Lake Winnebago and Lake Poygan. Fish from each lake tended to spawn in different areas, with relatively few sturgeon moving from one lake to another. Therefore, lake sturgeon populations in these two lakes should continue to be managed separately.

Lyster, L.L. 1939. Parasites of freshwater fish. I. Internal trematodes of commercial fish in the central St. Lawrence watershed. *Can. J. Res. Sect. D Zool. Sci.* **17**: 154-168.

Crepidostomum lintoni, recovered from lake sturgeon, were briefly described. Morphological features included: a size of 1 mm x 0.3 mm, prominent oral papillae, large oral sucker, pharynx one fifth of oral sucker, genital pore median close behind caecal fork, ventral sucker in anterior half of body and smaller than oral sucker, ovary lobed and pear shaped, lobed testes tandem or oblique and posterior to ovary, vitellaria lateral or dorsal meeting at terminal midline, broad flat muscular cirrus sac reaching posterior margin of acetabulum, and uterus reached up to the testes. A figure was provided.

Lytwyn, V.P. 1990. Ojibwa and Ottawa fisheries around Manitoulin Island: historical and geographical perspectives on aboriginal and treaty fishing rights. *Nat. Stud. Rev.* **6**: 1-30.

The history of fisheries around Lake Huron and Manitoulin Island was discussed. Sturgeon spawning runs were described in the Mississagi River around 1861. The description identified the Mississagi River as the principal sturgeon fishery in the Lake Huron region. It began at break-up and continued through autumn. Ojibwa [Ojibway, Ojibwe] living north of Lake Huron would assemble in large numbers near the mouth of the river. Fish were harvested primarily using gill nets made of sturgeon twine and hung from canoes; some were speared from platforms. The sturgeon were killed with a club. Swim bladders were sold to the Hudson Bay Company. Eighty to one hundred fish were taken per day, each weighing from 40 to 100 pounds. The aboriginals would smoke and dry the fish on poles to preserve them for winter use. Fur traders would purchase fresh, dried, or smoked sturgeon, as well as sturgeon oil and isinglass (derived from swim bladders). The amount of isinglass traded was listed from the years 1831 to 1863, with 1857 being the highest at 366 pounds, representing 3,600 sturgeon.

Lyubarskaya, O.D., and Lavrent'eva, I.L. 1985. Parasite fauna of the sterlet (*Acipenser ruthenus*) in the middle Volga River and Kuibyshev Water Reservoir, Russian-SFSR, USSR. *Parazitologiya (Leningr.)* 19: 320-323.

Twelve species of parasites, including *Polypodium hydriforme*, were recovered from an examination of 89 sterlet from the Volga branch of the Kuibyshev water reservoir. The fish ranged in age from 1 to 12 years old. Sampling was conducted in 1981-1982, twenty years after the reservoir was constructed.

MacCallum, W.G. 1895. On the anatomy of two distome parasites of freshwater fish. *Vet. Mag.* 2: 401-412.

Two distome digeneans, *Bunodera luciopercae* (Muller, 1776) Luhe, 1909, and *Homalometron armatum*, were described from the intestines of freshwater fish, including lake sturgeon, in Ontario.

MacCallum, W.R., Schram, S.T., and Schorfhaar, R.G. 1994. Other species: lake sturgeon, p. 73-76. In M. J. Hansen (ed.) *The state of Lake Superior in 1992*. Great Lakes Fish. Comm. Spec. Pub. 94-1. Available from www.glfc.org/pubs/SpecialPubs/Sp94_1.pdf [accessed 4 April 2006].

A brief history of lake sturgeon was provided, with the locations of spawning populations. Dam construction on streams used for spawning, and overharvesting, were the major historically limiting factors for sturgeon. Efforts to restore depleted stocks in different locations were discussed. Five recommendations were made for Lake Superior fish.

Macdonald, D.A. 1997. Management history of the Nelson River sturgeon fishery, p. 445. In *59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society*, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Macdonald, D. 1998. Five year report to the Nelson River Sturgeon Co-Management Board on Nelson River sturgeon studies 1993-1997. Manitoba Department of Natural Resources, Northeast Region. vii + 44 p.

A field program was conducted on a 200 km section of the Nelson River between Cross Lake

and Split Lake from 1992 to 1997. Lake sturgeon in this portion of the river had been subject to repeated commercial harvesting since early in the 20th century. The last period of commercial harvest exploited a relatively small remnant stock and, with signs of a declining population, the fishery was closed in 1992. Increasing domestic harvest by First Nations and concerns regarding the sustainability of commercial and domestic harvesting prompted the formation of the Nelson River Sturgeon Co-Management Board. Although efforts to reduce harvesting had been successful, sturgeon populations had continued to decline in the area. Complete closure of the commercial fishery was recommended or, if necessary, only the harvest of male sturgeon. Stocking the population with fingerlings might decrease the rehabilitation period. Educating fishermen and involving local communities were identified as key components of successful rehabilitation.

MacDonell, D.S. 1991. Enumeration and biological description of migrating fish in the Limestone River, Manitoba, 1990. North/South Consultants Inc., Winnipeg, MB. viii + 86 p.

A single lake sturgeon was caught in a downstream trap weir in the Limestone River. Measurements were taken and two Floy tags were attached below the dorsal fin. The fish was 1.15 m long, 5.6 kg, and 28 years old. There were no previous records of lake sturgeon using the Limestone River. In this case, the sturgeon probably used the river as a foraging alternative to the Nelson River.

MacDonell, D.S. 1992a. Final results of lake sturgeon radio telemetry studies conducted on the lower Nelson River between 1986 and 1992. North/South Consultants Inc., Winnipeg, MB. 26 p.

Radio telemetry studies were conducted on lake sturgeon between 1986 and 1992. Twenty-nine fish were tagged over a three year period with 90-day, one year, or 3 year transmitters. No significant movements were observed during the last 20 months of tracking. The movements of 12 sturgeon over a three to four year period were presented.

MacDonell, D.S. 1992b. Lower Nelson River tributary fish utilization studies: Angling and Kaikwasotasing Rivers, 1991. North/South Consultants Inc., Winnipeg, MB. viii + 90 p.

A study was conducted in 1991 to assess fish utilization of the Angling and Kaiskwasotasin rivers. A total of 5,004 larval fish and 13,981 juvenile and adult fish were captured. Nineteen species were caught, and 95% of the catch was comprised of white sucker and lake whitefish. Three lake sturgeon were captured with large mesh gillnets in the Angling River in the spring of 1991. One appeared to be migrating upstream and two downstream. No sturgeon were captured in the weir during the fall. The largest sturgeon was 1,065 mm in length and weighed 7,600 g. Ages ranged from 30 to 43 years. Each sturgeon was tagged but not recaptured during the study. Lake sturgeon likely used Angling River as a migration route between the Nelson River and Angling Lake, which may have provided forage and overwintering habitat.

MacDonell, D.S. 1993. Lower Nelson River tributary fish utilization studies: Weir, Kaiskwasotasin, and Roblin Rivers, and Broten Creek 1992. North/South Consultants Inc., Winnipeg, Manitoba. x + 123 p.

Twenty-nine lake sturgeon were captured in the spring near the mouth of the Weir River. Of these, 27 were captured in the mouth of the river, and 2 were taken from the Nelson River mainstem in the Weir River plume. All sturgeon appeared to be moving downstream when captured. No sturgeon were captured in the fall, likely due to low summer flows of the Weir River. The longest fork length was 1,250 mm and the heaviest weight was 19.3 kg. The smallest had a fork length of 772 mm and weighed 3 kg. The ages ranged from 18 to 56 years. Seventeen of the sturgeon showed evidence for present year reproductive activity, suggesting that they spawned in the lower reach or at the mouth of the Weir River. Twenty-six sturgeon were captured at the mouth of the Angling River in 1991, but none showed evidence of sexual maturity. All sturgeon caught were tagged with Floy tags, but only one was recaptured.

MacDonell, D.S. 1995. Lower Nelson River lake sturgeon spawning study: Weir River - 1994. Prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. vi + 32 p.

The objective of the study was to determine if, where, and when successful spawning occurred in the Weir River. A total of 26 adults and 4 larvae were captured with gill nets and drift nets,

respectively. Sturgeon used the river as staging habitat for spawning movements upstream. Spawning was believed to have occurred on June 16 at water temperatures of 11 to 17°C. Water flow regulation by hydroelectric structures may have affected lake sturgeon spawning movements and success.

MacDonell, D.S. 1996. Lower Nelson River tributary fish utilization studies: Limestone River, Years IV and V - 1994 and 1995. Report prepared by North/South Consultants Inc., Winnipeg, MB for Manitoba Hydro. x + 100 p.

The 1994 and 1995 results of a multi-year study to monitor impacts of construction of the Limestone Generating Station (G.S.) are presented. A total of 28 lake sturgeon were captured in gill nets set near the mouth of the Limestone River between June 6 and July 6, 1995. Four lake sturgeon captured in the area by a local fisher were also sampled. Total length ranged from 725 to 1,300 mm, with an average of 993 mm. Fork length ranged from 630 to 1,200 mm, with an average of 905 mm. Weight ranged from 1,500 to 11,250 g, with an average of 5,833 g. Ages ranged from 17-45 years, with an average of 29 years. The average catch-per-unit-effort was 0.53 sturgeon per 50 m of net per 24 hours. Six males showed external signs of current reproductive activity. One lake sturgeon had been tagged near Wilson Creek in the Limestone Forebay in 1991. This gave further proof of the emigration of lake sturgeon out of the Limestone Forebay and was noted as a possible critical limiting factor to sturgeon populations upstream of the Limestone G.S. No lake sturgeon larvae were captured in the spring of 1995.

MacDonell, D.S. 1997a. Lower Nelson River lake sturgeon spawning study: Weir River - 1996. North/South Consultants Inc., Winnipeg, Manitoba. 50 p.

A study was conducted in the spring of 1996 to assess the number and success of lake sturgeon spawning in the Weir River. By June 10, the pre-spawning congregation of sturgeon had peaked at the mouth of the river and movement upstream had commenced. Spawning was underway by June 14. Observations suggested that spawning occurred between June 10 and 20 at water temperatures ranging from 12 to 17.5°C. Newly hatched larvae were captured on June 28, suggesting an

incubation period of 10 days. Larvae caught in a drift trap suggested spawning occurred at least 2 km from the mouth. Spawning periodicity was 2 years for males, and 5 or more years for females. A minimum of 355 lake sturgeon used the mouth of the Weir River in 1996, the majority dispersing throughout the lower Nelson River in the summer. The Nelson River domestic harvest was estimated at about 2.6% of the population, and any potential increase in harvest would be of concern.

MacDonell, D.S. 1997b. The Nelson River lake sturgeon fishery from the perspective of the bayline communities of Pikwitonei, Thicket Portage, and Wabowden. Master of Natural Resources Management Thesis, Natural Resources Institute, University of Manitoba, Winnipeg, MB. ix + 173 p.

The purpose of this thesis was to collect local and historical knowledge from three Nelson River Sturgeon Co-management Board Bayline communities, namely, Wabowden, Thicket Portage and Pikwitonei. The history of the lake sturgeon commercial and domestic fisheries in the Nelson River were discussed. The information gathered fell into the following categories: distribution (historic and current), biology, cultural uses of sturgeon, changes since the construction of the Kelsey Generating Station, and stock status and current management. Recommendations included: 1) the collection of local knowledge from the remaining Co-management Board communities of Norway House, Cross Lake, and Split Lake; 2) expansion of public education programs; and 3) the incorporation of traditional knowledge into historical reviews of fisheries.

MacDonell, D.S. 1998. Lower Nelson River lake sturgeon spawning study Weir River - 1997. Prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. vii + 45 p. + apps.

Information was collected on lake sturgeon spawning at the Weir River. The number of sturgeon in the vicinity of the river mouth, spawning dates, spawning location, relative success of the spawn, and post-spawning dispersal were studied using gill nets, drift nets, visual surveys, and radio telemetry. Based on observed movements and data collected, spawning was believed to have occurred between June 14 and June 24 at water

temperatures ranging from 11 to 17°C. Radio telemetry data showed that sturgeon gathering near the Weir River mouth during spring dispersed throughout the lower Nelson River as far upstream as Limestone Generating Station and as far downstream as the Nelson River estuary, and into Angling Lake. Whether or not the Weir River was the only suitable spawning location is unclear. Twelve of the 346 sturgeon tagged in 1996 were recaptured in 1997 by domestic fishers. This suggested a mortality rate of 3.5% and was below the recommended 5%, but raised concerns for any potential increase in harvest.

MacDonell, D.S., and Bernhardt, W.J. 1992. A synthesis of fisheries studies conducted between 1985 and 1992 and general life history descriptions of fish species of the lower Nelson River. Report prepared by North/South Consultants Inc. for Manitoba Hydro, Winnipeg, MB. viii + 120 p.

A total of 202 lake sturgeon were captured during fisheries investigations of the lower Nelson River and its tributaries (Angling River, Angling Lake, Limestone River, Limestone Forebay, and Longspruce Forebay) between 1985 and 1992. Information on habitat, movements, overwintering, abundance, spawning, eggs, and impacts was summarized.

MacDonell, D.S., and Horne, B.D. 1994. Lower Nelson River forebay monitoring program 1993 - Year V. Unpublished report prepared by North/South Consultants Inc., for Manitoba Hydro, Winnipeg, MB. xii + 111 p.

The 1993 results of a multi-year study to monitor the response of northern fish populations to the impoundment of a large river were presented. Fisheries surveys were conducted in the Limestone Forebay, Long Spruce Forebay, and Stephens Lake. Four lake sturgeon (0.8% of catch) were captured in the spring with gill nets in the Limestone Forebay, and 8 (2.4% of catch) were captured in the same location in summer. One sturgeon was captured at Wilson Creek, 2 at Brooks Creek, and 9 below the Long Spruce spillway, or immediately downstream. Lake sturgeon were not captured in Long Spruce Forebay or Stephens Lake.

MacDonell, D.S., and Kitch, I.H. 1997. Lower Nelson River tributary fish utilization studies: Limestone and Weir rivers 1996. Report

prepared by North/South Consultants Inc., Winnipeg, MB for Manitoba Hydro. x + 79 p.

The results of the seventh year of an ongoing study to monitor the impacts of the construction of the Limestone Generating Station on fish populations were presented. One lake sturgeon was captured in the Weir River on August 29, 1996. It had a total length of 736 mm, a fork length of 665 mm, and a weight of 3,700 g. Results were compared to those from previous years.

MacDonell, D.S., and McRae, S.M. 1994. Lower Nelson River tributary fish utilization studies: Limestone River year III - 1992. North/South Consultants Inc., Winnipeg, Manitoba. vii + 56 p.

This report discussed the third year of a multi-year study to determine the significance of fish movement between the Limestone and Nelson rivers to fish in the lower Nelson River system. A total of 6,462 fish from 8 species were captured, mostly lake cisco (96%). The catch per unit effort for sturgeon near the mouth of the Limestone River was 2.1 fish per 100 m of net per 24 hour period. Of the ten lake sturgeon captured, none showed evidence of current year reproductive activity. Nine of them were captured in the quarry, an area that may provide an off-current refuge for this species during early summer.

MacDonell, D.S., Bretecher, R.L., and Remnant, R.A. 1992. Lower Nelson River tributary fish utilization studies: Limestone River and Moondance Creek year II, 1991. North/South Consultants Inc., Winnipeg, Manitoba. iv + 151 p.

This report discussed the second year of a multi-year study on fish movements, that was designed to determine the extent to which fish in the lower Nelson River system used the Limestone River and Moondance Creek. A total of 13,349 fish were captured in the Limestone River (11 species) and 1,823 in Moondance Creek (3 species). Lake cisco accounted for 87% of the catch in Limestone River, and longnose sucker 90% of the catch in Moondance Creek. Twelve lake sturgeon were captured from Limestone River, 2 moving upstream and 10 moving downstream. The downstream movement in late July suggested sturgeon migrated up the Limestone River in the spring

and were returning downstream in response to a decreasing discharge, or that the sturgeon spent the winter of 1990/91 in an upstream location in the Limestone River system. Lake sturgeon use of the Limestone River may have increased in 1991. Lake sturgeon ranged from 600 to 1,150 mm in length, weighed between 1,350 and 11,875 g, and were between 18 and 44 years of age. None showed signs of reproductive activity. Sturgeon caught in the Limestone River and Angling Lake were generally larger and older than those found in the Nelson River mainstem, suggesting that young sturgeon were not as common in tributaries of the lower Nelson River.

Mackay, H.H. 1963. Lake sturgeon, *Acipenser fulvescens* Rafinesque, p. 31-38. In *Fishes of Ontario*. Ontario Department of Lands and Forests, Toronto, ON.

The lake sturgeon was the largest of the native fishes in Ontario. A general account was provided of the natural history of this fish with information gleaned from referenced sources. There was a relatively rare drawing of a sturgeon otolith. Graphical representations of commercial sturgeon harvests from lakes Superior, Ontario, Erie, and Huron showed similar trends, namely, a near perpendicular increase in yields to a peak over a very short period (5-10 years) after fishing began, followed by a steep decline to negligible levels within the next 20 years. Introduction of the Eurasian freshwater sturgeon, *Acipenser ruthenus*, into selected Ontario rivers as a future target for fisheries was suggested.

Mackenzie, C. 2001. Lake Champlain fisheries restoration and management - Lake Champlain lake sturgeon survey and inventory. United States Fish and Wildlife Service, Lake Champlain Fisheries Resources Office, Federal Aid project in Vermont, F-35-R-3. Essex Junction, VT. 3 p.

This document was not available for annotating.

Mackenzie, C. 2002. Lake Champlain fisheries restoration and management - Lake Champlain lake sturgeon survey and inventory. United States Fish and Wildlife Service, Lake Champlain Fisheries Resources Office, Federal Aid project in Vermont, F-35-R-4. Essex Junction, VT. 3 p.

This document was not available for annotating.

Mackenzie, C. 2003. Lake Champlain fisheries restoration and management - Lake Champlain lake sturgeon survey and inventory. United States Fish and Wildlife Service, Lake Champlain Fisheries Resources Office, Federal Aid project in Vermont, F-35-R-5. Essex Junction, VT. 6 p.

This document was not available for annotating.

Mackenzie, C. 2004. Lake Champlain fisheries restoration and management - restoration of lake sturgeon. United States Fish and Wildlife Service, Lake Champlain Fisheries Resources Office, Federal Aid project in Vermont, F-35-R-6. Essex Junction, VT. 2 p.

This document was not available for annotating.

MacKenzie, C. 2005. Lake Champlain lake sturgeon sampling techniques. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 15 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 5 April 2006].

MacNeill, D., and Busch, W.D. 1994. The biology, history and management of the lake sturgeon in the lower Great Lakes. Sea Grant, Sportfishing Fact Sheet. Cornell Cooperative Extension and State University of New York. 7 p.

The general characteristics of lake sturgeon, such as range and distribution, feeding habits, morphology, behavior and movements, habitat requirements, general ecology, reproduction, and growth were described. The history and current status of lake sturgeon in the lower Great Lakes and management activities were also highlighted.

MacRitchie, I. 1983a. Rationale and recommended sturgeon quotas for large rivers in the Cochrane District of the Ontario Ministry of Natural Resources. Ontario Ministry of Natural Resources, Cochrane, ON. 13 p.

River hydrology, pollution, mercury contamination, spawning and life history, and surplus yield were considered in establishing

quotas. Five quota zones were designated in the Abitibi River and three in the Mattagami River. The recommended domestic commercial harvest was 0.20 kg per hectare per year, or 1,828 kg for all eight quota zones combined, for sturgeon in the 55 to 90 cm length range. The recommended U.S. commercial harvest was 0.28 kg per hectare per year, or 2,562 kg for all eight quota zones combined. Recommended quotas were given individually for each quota zone. Recommendations for the commercial fishery include the completion of a river survey, the determination of mercury contamination levels in sturgeon, continued sturgeon sampling to obtain vital statistics (fork length, whole weight, sex, pectoral fin for aging), the consideration of the selective removal of suckers to increase sturgeon productivity, a change in gear to 22.5 cm gillnets for which 90% of sturgeon caught are in the 50 to 90 cm range, and an incidental quota to avoid penalizing fishers for incidental catches.

MacRitchie, I. 1983b. Towards a river fish productivity estimator. The Frederick House River experience. Ontario Ministry of Natural Resources, Cochrane District, MS. Rep. 14 p.

This document was not available for annotating.

Madenjian, C.P., Fahnenstiel, G.L., Johengen, T.H., Nalepa, T.F., Vanderploeg, H.A., Fleischer, G.W., Schneeberger, P.J., Benjamin, D.M., Smith, E.B., Bence, J.R., Rutherford, E.S., Lavis, D.S., Robertson, D.M., Jude, D.J., and Ebener, M.P. 2002. Dynamics of the Lake Michigan food web, 1970-2000. *Can. J. Fish. Aquat. Sci.* **59**: 736-753.

Between 1825 and 1890, the lake sturgeon population in Lake Michigan was an estimated 145,000 to 2,406,000 sturgeon greater than or equal to 22.7 kg. This population collapsed in the early 1900s due to overfishing and habitat degradation. In the 1990s, small populations remained in at least 13 tributaries. The Lake Michigan lake sturgeon population may increase as dams on tributaries are removed and more spawning habitat becomes available.

Magnin, E. 1962. Recherches sur la systématique et la biologie des Acipenserides, *Acipenser sturio* L., *Acipenser oxyrinchus* Mitchill et *Acipenser fulvescens* Raf. *Ann. Stn. Cent. Hydrobiol. Appl.* **9**: 7-242.

The systematics and biology of three species of sturgeon, *A. sturio*, *A. oxyrinchus* and *A. fulvescens*, were reviewed. *A. fulvescens* was a well defined species and although the former two were less so, the author concluded that they were separate species. The growth of the three species of sturgeon was similar, and fin ray cross sections were a good method of determining age. Growth of all acipenserids continued throughout their life, but decreased after reaching sexual maturity. There was considerable variation in growth of sturgeon among individuals and geographical regions, but freshwater sturgeon grew slower. Young *A. oxyrinchus* migrated to salt water (estuarine water) whereas *A. fulvescens* were much more sedentary. Acipenserids fed primarily on benthic invertebrates, but the proportions of the major food items varied depending on the location. Sturgeon that fed in the ocean ate polychaetes. Fish were also eaten by sturgeon. A review of the literature was done to determine the properties of acipenserid plasma concerning minerals and how these values related to other species of fish, especially salmonids. Age to maturation for *A. sturio* was 18 to 20 years for females and 14 to 15 for males at Gironde; 27 to 28 for females and 22 to 24 for males of *A. oxyrinchus* in the St. Lawrence River and 21 to 22 for females and 17 to 18 for males of *A. fulvescens* in the St. Lawrence River. Using histological methods the author established five stages of maturation of the gonads for females and males.

Magnin, E. 1964a. Croissance en longueur de trois esturgeons d'Amérique du Nord: *Acipenser oxyrinchus* Mitchill, *Acipenser fulvescens* Rafinesque, et *Acipenser brevirostris* Le Seur. Verh. Internat. Verein. Limnol. **15**: 968-974.

This study dealt with the growth in length of lake and Atlantic sturgeon from the St. Lawrence waterway, and shortnose sturgeon from New Brunswick. The lake sturgeon was considered the longest lived of the three species. The annuli in the pectoral fin ray sections of lake sturgeon were clear and regularly spaced, unlike the Atlantic sturgeon where the annuli were often interrupted by secondary growth areas. This difference was attributed to the anadromous migration of the Atlantic sturgeon.

Magnin, E. 1964b. Premier inventaire ichthyologique du lac et de la rivière Waswanipi. Nat. Can. (Qué.) **91**: 273-280.

This report dealt with the first inventory of fish in Waswanipi Lake and River and was done during May 23 to June 28, 1963. The 156 lake sturgeon collected made up 7.36% of the total catch and had an average length of 72.7 cm and an average weight of 28.75 kg. A length-weight relationship and a length frequency distribution were given for lake sturgeon. A map of the watershed and sample areas was included.

Magnin, E. 1966a. Croissance de l'esturgeon *Acipenser fulvescens* Raf. vivant dans le bassin hydrographique de la rivière Nottaway, tributaire de la baie James. Trav. Pêche. Qué. **11**: 193-204.

Lake sturgeon from the Nottaway River basin, Québec were studied. A total of 316 sturgeon from eight lakes and the confluence of two rivers were collected from 1961 to 1963. Over 50% were caught in Lake Waswanipi. The average length of sturgeon ranged from 34 to 142 cm, weight from 0.195 to 21.25 kg, and age from 3 to 85 years. Sturgeon from Waswanipi and the St. Lawrence region were compared. Fish from the St. Lawrence population were larger and longer. Differences between the two populations were most pronounced for weight.

Magnin, E. 1966b. Quelques données biologiques sur la reproduction des esturgeons, *Acipenser fulvescens* Rafinesque de la rivière Nottaway, tributaire de la baie James. Trav. Pêche. Qué. **13**: 257-263. (and in Trav. Biol. Univ. Montréal **7**: 257-263).

Two hundred and sixty three sturgeon were examined from the Nottaway River system during June of 1963. A map of the region depicted the sampling sites and the location of numerous rapids that may provide spawning habitat. The sturgeon were separated based on length and age class. Immature females were 60-100 cm long and 13-23 years old; mature females 80-130 cm long and 17-28 years old; immature males 60-95 cm long and 13-21 years old; and, mature males were 70-130 cm long and 15-30 years old. Sturgeon could not be sexed until age nine. Spawning began in early June and lasted until the end of June.

Magnin, E. 1966c. Recherches sur les cycles de reproduction des esturgeons *Acipenser fulvescens* Raf. de la rivière Nottaway, tributaire de la baie James. Trav. Pêche. Qué. **16**: 1018-1024.

The reproductive cycle of the lake sturgeon in the Nottaway River was presented. Data were collected from 119 sturgeon, captured during and after spawning. Histological examination of the gonads determined the stage of development. Various stages of oocyte development were described. Immediately after spawning the gonads were very thin (2 cm diameter) with prominent transverse lamina. The ovary displayed numerous large resorbing unovulated eggs and many smaller oocytes (300 - 500 µm diameter). The early (second stage?) oocytes were un-pigmented yellowish, 1-1.8 mm in diameter and the cytoplasm was made of 5 distinct strata with the nucleus interior-most in position. These oocytes contained very small amounts of yolk granules. Stage III eggs were 2-2.7 mm in diameter, pigmented greyish-black, and contained three layers of yolk. The author felt that the transition from Stage II to III took more than a year and a further year to reach stage IV. The eggs of stage IV were slightly larger (2.5-2.7 mm) but not noticeably different from stage III eggs in terms of appearance. The change was considered to be one of internal reorganization. The author interpreted the data to indicate spawning every six years for female lake sturgeon of the Nottaway basin. The morphology and gross histology of the testes of active males were described. Males spawned every two years. While the spawning frequency in females decreased at more northern latitudes, it remained constant in males.

Magnin, E. 1977. Croissance, régime alimentaire et fécondité de esturgeons *Acipenser fulvescens* Rafinesque du bassin hydrographique de la Grand Rivière (Québec). Nat. Can. (Qué.) **104**: 419-427.

One hundred and twenty-seven sturgeon were collected from the Grande River Basin of Québec and their ages determined using pectoral fin ray sections. Ages ranged from 20 to 38 years, lengths from 721 to 1,080 mm, and weights from 621 (age 13) to 7,220 g (age 38). The main food items by frequency of occurrence were Pelecypoda (29%), Ephemeroptera (23%), Mollusca (15%), larval Trichoptera (12%), and larval Diptera (11%). Growth in length and weight of lake sturgeon from the St. Lawrence River, Lake Waswanipi and the Grande River basin were compared. Growth of sturgeon from the Grande River basin was the slowest with growth of sturgeon from Waswanipi being intermediate.

Magnin, E., and Beaulieu, G. 1960. Déplacements des esturgeons (*Acipenser fulvescens* et *Acipenser oxyrinchus*) du fleuve Saint-Laurent d'après les données du marquage. Nat. Can. (Qué.) **87**: 237-252.

A mark-recapture study on the St. Lawrence River from Three Rivers to Montmagny was conducted. Two thousand seven hundred and eighty fish were marked. Most of the sturgeon tagged and recaptured were in the 40 to 89 cm size range. The largest was in the 140-149 cm size class. Young sturgeon moved distances that did not exceed 48 km, and usually moved less than 16 km.

Magnin, E., and Harper, P.P. 1970. La nourriture des esturgeons *Acipenser fulvescens* de la Rivière Nottaway, tributaire de la Baie James. Nat. Can. (Qué.) **97**: 73-85.

The stomach contents of 55 lake sturgeon were collected from the Waswanipi River and Lake during the period May 23 to June 28, 1963. The main food items were benthic insect larvae belonging to the orders Trichoptera, Ephemeroptera, Diptera, Plecoptera, and Odonata. The Ephemeroptera were less frequent in young (3-5 years) and older (20-46 years) sturgeon. Mollusca were found in only seven of the stomachs examined, but were the main food item in these individuals. The frequency of molluscs in the diet was much higher in older fish, 20-46 years of age. Differences in diet between young and older sturgeon appeared to be primarily due to the type of habitat utilized.

Magnin, E., and Priegel, G.R. [1964?] Spawning periodicity of the lake sturgeon, *Acipenser fulvescens* Rafinesque, in Lake Winnebago, Wisconsin. Wisconsin Conservation Department, Oshkosh, WI. 14 p.

Three methods were used to examine lake sturgeon spawning periodicity in Lake Winnebago. These included summarizing the recapture of sturgeon that were tagged on the spawning grounds, an examination of the gonads of sturgeon harvested in the spawning period that were tagged in Lake Winnebago but had no spawning history, and an examination of the gonads of sturgeon tagged on the spawning grounds and harvested in Lake Winnebago. The results were summarized and similar for all methods used. Most males spawned every

second year, but some spawned annually or at intervals of three or more years. Most females had a 4 year spawning cycle, but some spawned every five or six years. Results were compared to those from previous studies.

Maier, E.M. 1974. Coelenterata, p. 40-41, illustr. In F. D. Mordukhai-Boltovskogo (ed.) Atlas of the Aral Sea invertebrates. Pishchevaya Promyshlennost, Moscow, 197. 271 p.

This item was not available for annotating.

Mailhot, Y., and Dumont, P. 1997. Status and management of lake sturgeon (*Acipenser fulvescens*) stock in the St. Lawrence River, Québec, Canada, p. 444. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Malott, M.L., Ferguson, M.M., and McKinley, S. 1992. Mitochondrial DNA analysis of lake sturgeon (*Acipenser fulvescens*). In Report on the Operation of the Clemens-Rigler Travel Fund in Support of Student Attendance at the Canadian Conference for Fisheries Research (CCFFR) and the Conference of the Society of Canadian Limnologists (SCL), Halifax 1992, and Report on the 45th Canadian Conference for Fisheries Research CCFFR 1992. Pagination unknown. [Abstract only].

Mandrak, N.E., and Crossman, E.J. 1992. Postglacial dispersal of freshwater fishes into Ontario. Can. J. Zool. 70: 2247-2259.

The present-day distribution of native freshwater fishes of Ontario in relation to processes of the Wisconsinan glaciation was discussed. Refugia were determined using a refugial index, and by identifying glacial water bodies used as dispersal routes. Lake sturgeon likely dispersed from the Mississippian refugium along the Warren, Brule-Portage, and Chicago dispersal routes.

Manitoba Conservation. 2003. A profile of Manitoba's commercial fishery. Manitoba Conservation, Fisheries Branch, Winnipeg, MB. 6 p. + figs., tables. Available from <http://www.gov.mb.ca/conservation/fish/images/history.pdf#search='a%20profile%20of%20Manitoba%27s%20commercial%20fishery'> [accessed 5 April 2006].

Allocation of licenses, commercial production and value, marketing, transportation logistics, and transportation costs were discussed. Table 1 provided commercial fishery harvest statistics by species from 1992 to 2002. Sturgeon were harvested until 1996. A total of 1,600 kg were harvested in 1992/93 (\$12,570), 200 kg in 1993/94 (\$3,550), 500 kg in 1994/95 (\$3,802), and 600 kg in 1995/96 (\$3,940). The values of the harvests were presented in Table 2 and based on the 2003 market.

Manitoba Conservation. 2004. 2004 final stock report. Winnipeg, Manitoba. 4 p. Available from <http://www.gov.mb.ca/conservation/fish/images/04stock.pdf> [accessed 5 April 2006].

This document summarized stocking efforts in Manitoba in 2004. Information includes waterbody, date, species, size, number, and location description. The Winnipeg River was stocked with 221 adult lake sturgeon on July 26, and 2,150 fingerlings on August 18. The Nelson River was stocked with 1,300 lake sturgeon fingerlings on September 14.

Manitoba Natural Resources. 1991. Manitoba fisheries strategy. Fisheries Branch, Manitoba Natural Resources. i + 29 p.

Lake sturgeon, native to the Nelson River, were identified as a heritage species affected by hydroelectric developments. The author stated that management practices would emphasize the preservation of heritage species where the situation arose.

Manny, B.A., and Kennedy, G.W. 2002. Known lake sturgeon (*Acipenser fulvescens*) spawning habitat in the channel between lakes Huron and Erie in the Laurentian Great Lakes. J. Appl. Ichthyol. 18: 486-490.

Bottom substrates were examined and photographed using a high-resolution underwater video camera to determine the kinds of substrate present and differences in water quality at spawning sites. Substrates identified were rounded cobble (10-40 cm in diameter) and coarse gravel (2-8 cm in diameter) of glacial origin, or coal cinders (0.5-12 cm in diameter) of human origin. The percent of light reaching the bottom ranged from 0.05 to 8.7%, secchi disc depth from 2.5 to 6.5 m, and water velocity ranged from 0.35 to 0.98 m/s and varied significantly between sites. Water depth ranged

from 9-12 m, generally greater than that of known sturgeon habitat elsewhere.

Manny, B., Kennedy, G., Allen, J., and McClain, J. 2005. Classification of lake sturgeon spawning habitat in the Detroit River. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 18 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 5 April 2006].

Manny, B.A., Read, J., Kennedy, G.W., Denison, D., Caswell, N.M., Boase, J., Koproski, S., McClain, J.R., Reider, R.H., and Taylor, W. 2004. Creation of lake sturgeon spawning habitat in the Detroit River. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Restoration of lake sturgeon in the Detroit River was limited by available spawning substrate. In 2004, three lake sturgeon spawning beds were constructed of 8-16 inch broken limestone, 4-12 inch metamorphic cobble and gravel, and 1-4 inch coal cinders. Each bed was 4,000 square feet and located at depths of 22-28 feet in water flowing 2-3 feet/s. Telemetry studies of sturgeon that spawn on these beds will begin in 2005 and 2006.

Maraldo, D. 1997. Recovery of lake sturgeon, *Acipenser fulvescens*, in Lake Nipissing, Ontario, p. 448. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Marion, C., and Peterson, D. 2004. Reintroduction of lake sturgeon in the Coosa River system of Northwest Georgia. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Recent habitat and conservation activities in the Coosa River system have improved water quality and other habitat parameters necessary for lake sturgeon survival. The Georgia Department of Natural Resources began a long-term reintroduction program, releasing several thousand juvenile lake sturgeon into two major

tributaries of the Coosa River in the fall of 2003. Bottom-set gill nets were set to assess survival of age-1 sturgeon. The objective of this study was to define controlled scientific protocols for monitoring the success of this program, which may also be used as a model for fish restoration in Georgia and other southeastern states.

Mark, B.D., Porter, B., Cavender, T.M., and Fuerst, P.A. 1997. Use of RAPDS to study population structure of lake sturgeon in the Great Lakes, p. 563. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Markets and Economic Service, Department of Fisheries of Canada. 1955. The Canadian commercial fisheries of the Great Lakes. Basebook on Fisheries Statistics No. 2: Various pagination.

Canadian commercial harvests and value statistics were presented by species for Lake Ontario, Lake Erie, Lake St. Clair, Lake Huron, Georgian Bay and Lake Superior from 1867 to 1953 (values were only given from 1945-1953). Lake sturgeon harvest in Lake Ontario peaked in 1882 at 1,032,000 pounds (dressed weight); in the ensuing years harvest declined and fluctuated. The 1953 harvest was 128,000 pounds (\$12,815). Lake Erie commercial harvest peaked in 1887 at 6,096,000 pounds. By 1953, harvest had declined to 63,000 pounds (\$8,563). Lake St. Clair harvest peaked in 1879 at 920,000 pounds; the harvest declined and fluctuated in the years following. By 1953, harvest had declined to 105,000 pounds (\$9,458). The Lake Huron commercial harvest peaked in 1886 at 8,343,000 pounds. In 1953, 211,000 pounds were harvested (\$22,304). The Georgian Bay commercial harvest peaked in 1893 at 4,693,000 pounds. By 1953, harvest had declined to 10,000 pounds (\$890). Lake Superior commercial harvest peaked in 1887 at 1,210,000 pounds. In 1953, 40,000 pounds were harvested (\$3,825).

Markov, G.S., Trusov, V.Z., and Reshetnikova, A.V. 1964. Title unavailable. *Vch. Zap. Volgogradsk. Ped. Inst.* 16: 111.

Cited in Andreev and Markov (1971), referring to the occurrence of *Polypodium* in sturgeon during certain times of the year.

Martin, R., and Layzer, J.B. 2001. Persistence and movement of captive-reared lake sturgeon (*Acipenser fulvescens*) released into the French Broad River, Tennessee. In American Fisheries Society 131st Annual Meeting. 2001: A Fisheries Odyssey - The Journey of Science and Education Continues. Phoenix, AZ, 19-23 August, 2001. Pagination unknown. [Abstract only].

Mason, G. 1991. Review of "Cross Lake Band of Indians domestic sturgeon fishing claim-proposed basis for settlement (final report)". Prairie Research Associates Inc. (PRA), Winnipeg, MB. 7 p.

The survey methodology used by Symbion Consultants to determine the amount of fish captured and consumed by the Cross Lake community before and after the construction of Jenpeg was reviewed. In the report, Symbion Consultants admitted that the survey was not "scientifically valid", but it was nonetheless used to support the claims that the sturgeon fishery had declined and was highly valued by the community. Sources of bias were summarized and it was concluded that the estimates of consumption prior to Jenpeg were significantly over estimated.

Masuda, H., Amaoka, K., Araga, C., Uyeno, T., and Yoshino, T. 1984. Fishes of the Japanese archipelago. Tokai Univ. Press, Tokyo. Pagination unknown.

Photographs (in plates) were accompanied by brief descriptions of the five species of sturgeon recognized from the Japanese archipelago.

Mathers, A. 2000. Update on lake sturgeon in the Canadian waters of Lake Ontario and the St. Lawrence River, January 2000, p. 6-7. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 5 April 2006].

Mattes, W., and Nelson, J. 2001. Namé (lake sturgeon) project on the White River in Wisconsin during 2001. United States Fish and Wildlife Service, Ashland Fisheries Resources Office, Ashland, WI. 23 p.

This document was not available for annotating.

May, B., Krueger, C.C., and Kincaid, H.L. 1997. Genetic variation at microsatellite loci in sturgeon: primer sequence homology in *Acipenser* and *Scaphirhynchus*. Can. J. Fish. Aquat. Sci. **54**: 1542-1547.

Eleven tri- and tetra-meric motif microsatellite loci were identified in a lake sturgeon genomic library and were tested against 6 North American species of *Acipenser* and 2 species of *Scaphirhynchus* using 4 individuals of each species. Eight loci were amplified in all eight species, and three loci amplified in two, four, and seven species respectively. Of the eight loci amplified well in all species, one was monomorphic in all species, while the remaining seven were polymorphic in three to eight species. Single repeat differences in repeat motifs were readily scored on 4% Metaphor agarose gels stained with ethidium bromide. Dosage for loci exhibiting four gene doses could also be readily scored with this technique. These loci represented genetic markers that should work well in threatened and endangered species of sturgeon worldwide.

McAllister, D.E., and Coad, B.W. 1974. Fishes of Canada's National Capital Region. Can. Nat. Mus. Nat. Sci. Misc. Spec. Publ. **24**: 36-37.

This brief account contained an original description based on eight specimens. The authors suggested that the lake sturgeon invaded the Ottawa River basin from a Mississippian refugium via the lower Great Lakes and St. Lawrence River.

McAllister, D.E., and Crossman, E.J. 1973. A guide to the freshwater sport fishes of Canada. Can. Nat. Mus. Nat. Sci. Nat. Hist. Ser. **1**: 20.

A brief (one paragraph) account of the size, distribution and general biology of lake sturgeon was offered. A diagram of the sturgeon and a distribution map were provided.

McCart, P. 1992. Nelson River sturgeon fishery: maximum sustainable yield and the impact of hydroelectric development. Prepared for Manitoba Hydro by Aquatic Environments Limited. 15 p. + tables, figs.

This report examined the level of maximum sustainable yield (MSY) for lake sturgeon within

the Resource Area of the Cross Lake Band of Indians and how it may have been impacted by the Jenpeg hydro development. MSY cannot be calculated for sturgeon stocks in most lakes because their populations were depleted in the late 19th and early 20th centuries and only remnants are left. The only lake for which a reliable MSY is available is Lake Winnebago, Wisconsin (0.23 kg/ha/yr). MSY for more northerly stocks is likely to be less due to their lower productivity. Historical commercial harvests statistics were included. Harvests were generally greater in small lakes than in large ones, possibly because small lakes have a greater proportion of shallow areas which are preferred by lake sturgeon. If MSY also varies with lake size, small lakes should have a higher MSY than large lakes. A review of the literature revealed that MSY for sturgeon populations living in rivers during the growing season may be higher than those of populations restricted to lakes except during the spawning season. In 1961, Sunde estimated the sustainable commercial yield for Sipiwesk Lake and 59 km of the Nelson River as 0.069 kg/ha/yr. Yields from the Native fishery were not estimated. Estimates of the MSY for the Native fishery before and after Jenpeg were compared. It was noted that any estimate of MSY for the Native fishery in this area is hypothetical, since the size of the fishery is in dispute.

McClain, J.R. 1997a. Preliminary evaluation of the current status of lake sturgeon (*Acipenser fulvescens*) in Michigan waters of Lake Huron - a progress report for 1995 and 1996. United States Fish and Wildlife Service, Alpena Fisheries Resource Office, Alpena, MI. 9p. Available from <http://www.fws.gov/midwest/alpena/rpt-stnpre97.html> [accessed 5 April 2006].

This project gathered information on the status and trends of lake sturgeon in Lake Huron needed for the final determination of federal listing status. Data were collected by commercial fishers from lake sturgeon caught as by-catch in their trap net fishery. Total length, fork length, girth and weight were measured and lake sturgeon were tagged. A total of 53 lake sturgeon had been sampled since 1995, with only 3 coming from outside Saginaw Bay. Most captures occurred in the months of May and October. Biological data were summarized.

McClain, J.R. (ed.) 1997b. Summary of the 1996 activities of the Interbasin Lake Sturgeon Working Group in waters of Lakes Huron, St. Clair, and Erie. United States Fish and Wildlife Service, Alpena Fishery Resource Office, Alpena, Michigan. 10 p. Available from <http://www.fws.gov/midwest/alpena/rpt-stnib96.html> [accessed 5 April 2006].

Lake sturgeon sampling was completed at two sites with the help of commercial fishermen on Lake Huron. One hundred and eighty-three lake sturgeon were sampled, 58 from southern Lake Huron and the remainder from the North Channel. Depth and substrate information were also collected from a group of 40 samples in the North Channel only. The average depth of capture was 13.8 m, with the deepest at 27.4 m and the shallowest at 6.4 m. The deepest fish were sampled in May and the shallowest in June and November. One hundred and twenty-two lake sturgeon were tagged, with 31 in southern Lake Huron and 91 in the north channel, bringing the total of tagged fish in the area to 75 in southern Lake Huron and 176 in the North Channel in the last two years. Several fish tagged in 1995 were recaptured, generally in about the same locations as the previous year. More fishermen reported seeing many more young sturgeon than in previous years. The group reported 1996 as a successful year overall.

McClain, J.R., and Hill, T.D. 1999. Activities of the Central Great Lakes Bi-National Lake Sturgeon Group in 1997 and 1998. Presented at Great Lakes Fishery Commission Lake Huron Committee Meeting, Milwaukee, WI, March 22-23, 1999 and Lake Erie Committee Meeting, Grand Island, NY, April 1, 1999. 63 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-stnib97-98.pdf> [accessed 5 April 2006].

This document provided a summary of research conducted in 1997 and 1998 in Lake Huron, the St. Clair Waterway, Lake Erie and the Niagara River/Lake Ontario. In the Canadian waters of Lake Huron, 617 lake sturgeon were sampled from the by-catch of the commercial fishery in 1997. A summary of morphological and habitat data was given. Similar data were collected by the USFWS in the U.S. waters of Lake Huron and a description was given. Sampling by the Michigan Department of Natural Resources continued in the St. Clair River and trawling in

Lake St. Clair. From 1996 to 1998, 510 lake sturgeon had been tagged. The age distribution and habitat use were discussed. Work completed on a project examining spawning and movements of lake sturgeon in the St. Clair River system by the University of Michigan School of Natural Resources and Environment was summarized. Also included was a summary of USFWS work in the Detroit River. This project aimed to fill in data gaps on lake sturgeon and their habitats. In Lake Erie, the Ohio Division of Wildlife recorded 109 reported lake sturgeon sightings during 1997 and 1998. The length frequency distribution was given. In the Canadian waters of Lake Erie, the Ontario Ministry of Natural Resources continued to collect biological data on lake sturgeon caught as by-catch in the commercial fishery. A total of 40 lake sturgeon were caught in 1997. The length frequency distribution and length to girth relationship were given. Lake sturgeon sightings and sampling efforts in the Niagara River were summarized by the USFWS Lower Great Lakes Fishery Resources Office. A project on the Oswegatchie River examining the success of restoration efforts was also discussed.

McClain, J.R., and Manny, B.A. 2000. Evaluation of lake sturgeon habitat in the Detroit River. Prepared for United States Environmental Protection Agency (USEPA) – Great Lakes National Program Office (GLNPO). Report No. **GL98105**: 25 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-detrstnhab99.pdf> [accessed 5 April 2006].

Eleven lake sturgeon were caught in the Detroit River between May and October of 1999. Total length, fork length, girth and weight were measured and this data was summarized. The leading left pectoral fin ray was removed for aging, and a portion of the distal fin ray was removed for genetic analysis. Each lake sturgeon was tagged. All were nonspawning subadults and adults, 7-38 years old. None were in spawning condition because sampling started too late. The ideal spawning temperature (13°C) was reached before field sampling began. It was recommended that future sampling begin earlier in spring. Spawning habitat was discussed.

McClain, J.R., Hill, T.D., Lowie, C.E., Mohr, L., Thomas, M., Haas, R., Davies, D., and MacLennan, D. 1997. The use of non-target and anecdotal information to assess remnant lake sturgeon populations, p. 446. *In* 59th

Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

McCormick, B.J., Sheehan, R.W., and Turcotte, N. 1990. Ontario Hydro incident report - Sturgeon relocation at Adam Creek July/August 1990. Ontario Hydro, Environmental Studies and Assessments. 5 p. + app.

This report described the passage of sturgeon through the Adam Creek control structure and summarized the events and issues following the spill at Adam Creek in July of 1990. Appendix A recounted the sturgeon relocation activities and statistical information recorded from each fish. Appendix B contained organizational notes recorded by planners.

McDonald, M., Arragutainaq, L., and Novalinga, Z. 1997. Voices from the Bay: traditional ecological knowledge of Inuit and Cree in the Hudson Bay bioregion. Canadian Arctic Resources Committee; Environmental Committee of Municipality of Sanikiluaq, Ottawa, ON. xiii + 98 p.

This document presented findings of the Hudson Bay Traditional Ecological Knowledge and Management Systems (TEKMS) study. Chapter headings included: traditional knowledge of ecosystem components; environmental change and its significance to Inuit and Cree; indigenous perspectives on development; and future needs. Sturgeon were noted on page 44 as one of the fish species losing river spawning sites in eastern James Bay, western Hudson Bay, and southern James Bay. They were also noted as being in decline due to hydroelectric developments in the area. Quotes from locals on the sensitivity of sturgeon to water quality are included in Appendix D.

McEnroe, M., and Cech, J.J. 1994. Seasonal change in concentration of thyroid hormone, T₃ and T₄, in the plasma of juvenile white sturgeon, *Acipenser transmontanus*, p. 17. *In* The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

McEnroe, M., and Marshall, J. 1994. Salinity tolerance and development of chloride cells in juvenile white sturgeon: possible implication for

water diversions, p. 16. In The International Conference on Sturgeon Biodiversity and Conservation. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

McKinley, R.S., Sheehan, R.W., and Kowalyk, H. 1991. Seasonal distribution and movement of radio tagged walleye and lake sturgeon in the vicinity of the proposed Mattagami hydroelectric extensions. Ontario Hydro Research Division Report No. 91-104-K: vi + 46 p.

Fifty adult and 10 juvenile lake sturgeon were collected with gillnets near the Little Long Generating Station forebay and fitted with external radio transmitters. These individuals were tracked once per month before and after spring freshet using a fixed-wing aircraft. During spring freshet, tracking occurred weekly. Fixed antennae stations were also in place to monitor passage through hydroelectric facilities and their spillage downstream through the control structures into the Adam Creek diversion channel. Most radio-tagged sturgeon were at least 30 km south of the hydraulic facilities during spring freshet, suggesting that their vulnerability to passage through the stations or control structures was limited. At least half of the lake sturgeon radio-tagged north of the Kipling generating station inhabited a 30 m deep basin directly below the stations' spill structures during the spring freshet periods of 1989 and 1990. Limitations of and recommendations for radiotelemetry were discussed.

McKinley, R.S. 1993. Migratory behaviour, seasonal activity and condition levels in lake sturgeon in the vicinity of a hydroelectric facility. Ph.D. Thesis, University of Waterloo, Waterloo, ON. xi + 130 p.

This thesis was not available for annotating.

McKinley, R.S., and Power, G. 1992. Measurement of activity and oxygen consumption for adult lake sturgeon (*Acipenser fulvescens*) in the wild using radio-transmitted EMG signals, p. 307-318. In I.G. Priede and S.M. Swift (ed.) Wildlife telemetry: remote monitoring and tracking of animals. Ellis Horwood Limited, New York.

The use of electromyogram (EMG) signals to measure activity and oxygen consumption in both laboratory and field settings was tested.

The relationship between oxygen consumption and swimming speed at three acclimation temperatures was determined in the laboratory. The scope for activity (maximal oxygen uptake minus standard metabolism) was 105, 90, and 75 mg O₂ kg⁻¹ h⁻¹ at 19, 10 and 5°C, respectively. EMG signals were then monitored in the field for one week periods in summer, fall and early winter. Sturgeon were less active at warmer summer temperatures than at fall and winter temperatures. Cost of activity in summer was on average less than 50% of the available scope for activity, in fall it was slightly more than 50% and in winter it exceeded the available scope for activity. This anomaly indicated a need for further studies on sturgeon muscle function at low temperatures. Sturgeon had a low metabolic rate and scope for activity compared to species of similar size and acclimation temperature. Because they were more susceptible to changes in water flow, energetic effects on sturgeon should be taken into account when considering hydroelectric development.

McKinley, R.S., Singer, T.D., Ballantyne, J.S., and Power, G. 1993. Seasonal variation in plasma nonesterified fatty acids of lake sturgeon (*Acipenser fulvescens*) in the vicinity of hydroelectric facilities. Can. J. Fish. Aquat. Sci. 50: 2440-2447.

Seasonal variations in plasma nonesterified fatty acids (NEFAs) upstream and downstream from hydroelectric stations were recorded over a two year period. During the spring, significantly higher levels of total plasma NEFA were found in lake sturgeon upstream than in those downstream of generating stations. NEFA profiles for key fatty acids differed significantly among seasons, especially during the spring and summer. Levels of oleic acid were highest upstream and levels of docosahexaenoic acid were higher downstream of the stations. Differences in plasma NEFA concentration were attributed to altered nutritional status because of varying water flow regimes downstream of the generating stations.

McKinley, S., Van Der Kraak, G., and Power, G. 1998. Seasonal migrations and reproductive patterns in the lake sturgeon, *Acipenser fulvescens*, in the vicinity of hydroelectric stations in northern Ontario. Environ. Biol. Fishes 51: 245-256.

Seasonal migratory behavior and reproductive patterns of lake sturgeon were examined in a portion of the Mattagami River where water flow was regulated by hydroelectric structures. The distribution of fish was related to the migration of fish to spawning sites in the spring, post-spawning movement to feeding areas, and late summer migration to an area of concentration on the Groundhog River. A high proportion of fish of reproductively active size was found in the vicinity of appropriate spawning habitat in early May. Measurement of the gonadosomatic index (GSI) revealed that female sturgeon had a prolonged period of ovarian regression after spawning, with recommencement of ovarian development occurring in September. This was indicated by a rise in the GSI and plasma levels of testosterone and 17β -estradiol. On the other hand, male sturgeon began testicular recrudescence within one month after spawning. Male GSI reached prespawning levels by September, while reproductive hormones were back to pre-spawning levels by June. The hydroelectric projects on the Mattagami River system have had significant effects on lake sturgeon. The altered river flow seemed to enhance reproductive development.

McLeod, C., Hildebrand, L., and McKenzie, S. 1997. Fraser River white sturgeon monitoring program. *In* Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

McLeod, C., Hildebrand, L., and Radford, D. 1997. Management of lake sturgeon sport fisheries in Alberta. *In* Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

McLeod, C., Hildebrand, L., and Radford, D. 1999. A synopsis of lake sturgeon management in Alberta, Canada. *J. Appl. Ichthyol.* **15**: 173-179.

Lake sturgeon harvest was prohibited in Alberta from 1940 to 1968, after which limited harvest was permitted. Studies have been done primarily on the South Saskatchewan River based on mark-recapture data. The population size was approximately 3,700 fish. Recent studies in the North Saskatchewan River indicated a population of about 1,300 fish. A portion of the population in both rivers was

transboundary, moving between Saskatchewan and Alberta. This was of special concern because of different angling regulations. Water uses have also contributed to the decline of lake sturgeon in Alberta. After assessment of past management practices, Alberta Environmental Protection implemented a number of regulatory changes in 1987 to further protect lake sturgeon while providing angling opportunities and maintaining a controlled harvest.

McLeod, D.T. 1999. An assessment of lake sturgeon populations in the lower Seine River system, Ontario, 1993-95. Ontario Ministry of Natural Resources, Fort Frances District. i + 28 p.

This study examined the abundance and population dynamics of lake sturgeon and, their movement patterns in the Lower Seine River system and surrounding areas, and assess the impact of the current rate of exploitation. The methods included netting and tagging, commercial catch sampling, harvest assessment and habitat assessment. The average commercial harvest from 1967 to 1995 was 195 kg/yr. The commercial quota was 182 kg/yr and the target harvest recommended by the Border Waters Lake Sturgeon Committee was 145 kg/yr. The annual rate of recruitment into the commercial fishery was low for this population, with a range of 0 to 5.6% and an average of 2.2% between 1993 and 1995. Recommendations included: determining annual native subsistence harvest levels, monitoring water levels and establishing minimum flow guidelines for the Sturgeon Falls Dam for critical life history periods, continuing monitoring and sampling commercial catch, a radiotelemetry study, genetic analysis, continuing habitat assessment, larval drift net sampling, and an aquatic habitat inventory for the entire Lower Seine River system.

McLeod, D.T., and Chepil, L. 1999. A preliminary examination of the fish community in the lower Seine River system, Ontario, 1993. Ontario Ministry of Natural Resources, Fort Frances District. i + 29 p.

The purpose of this study was to determine the abundance of fish and species composition in the lower Seine River system and contaminant levels in commonly consumed species; to assess the status of stocks and the impact of current exploitation rates; and to examine the

population characteristics for sport, subsistence, and all species subject to gillnet catches. Eight hundred and eighty-seven fish were captured representing 15 different species. Of these only one lake sturgeon was caught and no further analysis was undertaken. The focus of the report was on walleye and northern pike.

McMurty, M.J., Willox, C.C., and Smith, T.C. 1997. An overview of fisheries management in Lake Simcoe. *Lake Reservoir Manag.* **13**: 199-213.

Over the past 150 years, significant changes have occurred in the ecology of Lake Simcoe in response to eutrophication, increasing fishing pressures, habitat destruction, non-native invasive species, and other factors. The extirpation of lake sturgeon, decline of muskellunge, and recruitment failure of lake trout and lake whitefish were observed. Early conservation actions involved the restriction of commercial fishing and controls on sport fishing, supplemental stocking of native fish, and the stocking of non-native fish. Management decisions have greatly improved in the last 30 years.

McPhail, J.D., and Lindsey, C.C. 1970. The sturgeons - Family Acipenseridae, p. 60-61. *In* *Freshwater Fishes of Northwestern Canada and Alaska*. Fish. Res. Board. Can. Bull. **173**.

A key to sturgeon of northwestern Canada and Alaska was provided. Green sturgeon (*Acipenser medirostris*), white sturgeon (*A. transmontanus*), lake sturgeon (*A. fulvescens*) and Siberian sturgeon (*A. baeri*) were included.

McQuown, E. 2000. Inheritance of microsatellite loci and delineation of lake sturgeon (*Acipenser fulvescens*) population genetic structure. M.Sc. Thesis, University of California, Davis. Pagination unknown.

This document was not available for annotating.

McQuown, E., Gall, G.A.E., and May, B. 2002. Characterization and inheritance of six microsatellite loci in lake sturgeon. *Trans. Am. Fish. Soc.* **131**: 299-307.

Six microsatellite loci were used to study inheritance patterns in six lake sturgeon families. Three of the loci (*Sp1120*, *Aox27*, and *Afu68b*) conformed to a disomic Mendelian inheritance

model, homologous loci were noted for *Aox27* and *Afu68b*. The other three loci (*Sp135*, *Sp1101*, and *Sp1106*) possessed banding patterns, gametic segregation patterns, and evidence suggestive of double-reduction events in the descendants. These characteristics support a tetrasomic mode of inheritance, and suggest a shift in the lake sturgeon genome from tetrasomy to disomy.

McQuown, E., Krueger, C.C., Kincaid, H.L., and Gall, G.A.E. 2000. Analysis of lake sturgeon population structure with microsatellite data, p. 10. *In* C. Lowie (ed.) *Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization*. Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **2000-01**. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 5 April 2006].

McQuown, E., Krueger, C.C., Kincaid, H.L., Gall, G.A.E., and May, B. 2003. Genetic comparison of lake sturgeon populations: differentiation based on allelic frequencies at seven microsatellite loci. *J. Gt. Lakes Res.* **29**: 3-13.

Lake sturgeon ($n=210$) were studied to determine their genetic variation. They were sampled from seven sites, including the St. Lawrence, Des Prairies, Mattagami, Menominee, Wolf and Niagara rivers, and Lake Erie. The seven microsatellite loci examined were highly variable, with an average of 8.6 alleles per locus and heterozygosity values at the four disomic loci ranging from 0.46 to 0.66. Three distinct population groups were delineated using Nei's genetic distance values, indicating that lake sturgeon populations were differentiated within the Great Lakes drainage basin. Managers should consider these results when developing restoration and conservation programs.

McQuown, E.C., Sloss, B.L., Sheehan, R.J., Rodzen, J., Tranah, G.J., and May, B. 2000. Microsatellite analysis of genetic variation in sturgeon: new primer sequences for *Scaphirhynchus* and *Acipenser*. *Trans. Am. Fish. Soc.* **129**: 1380-1388.

Clones ($n = 172$) were sequenced from three subgenomic libraries of shovelnose sturgeon *Scaphirhynchus platyrhynchus*. These libraries were then enriched with two dinucleotide and tetranucleotide microsatellite motifs. The primers were tested against shovelnose, pallid, white, lake, and green sturgeon. In *Scaphirhynchus* species, 93% of the 113 primer sets tested amplified loci, and 76% were polymorphic. Polymorphic systems usually showed disomic banding patterns. In *Acipenser* species, 65%-80% of loci amplified and 42%-58% were polymorphic. This genus usually showed tetraploid or higher level polyploid banding patterns.

McRae, S.M., and Remnant, R.A. 1997. Results of a questionnaire on domestic harvesting in the lower Churchill River area, 1996. Unpublished report prepared by North/South Consultants Inc., Winnipeg, MB for Manitoba Hydro. xi + 84 p.

Survey questionnaires were mailed to 155 domestic harvesters at 89 residences. Fifty-eight surveys were returned, five of them incomplete, for a response rate of 34%. Between May of 1995 and April of 1996, respondents fished for sturgeon in the Churchill Estuary and Morrier Island area in spring, summer and fall, and in the Long Island area in summer. During this period, one sturgeon was reported harvested for personal consumption. It was taken in summer. Prior to the Churchill River Diversion in 1976, respondents reported fishing for sturgeon at the Churchill Estuary, Morrier Island and upper Churchill River in spring, summer and fall, and at the Churchill Estuary and upper Churchill River in winter.

Mecozzi, M. 1988. Lake sturgeon (*Acipenser fulvescens*). Wis. Dept. Nat. Res. Bur. Fish. Manage. PUBL-FM-704 88: 6 p.

The distribution, habits and habitat, life cycle, identification, fishing methods, and environmental concerns relating to lake sturgeon were discussed with special reference to Wisconsin waters. Spawning was dependent upon water temperature and flow, and did not begin until water temperatures reached 58-59°F if the flow was low or 53°F if the flow was high. Males matured at 15 years and usually spawned in alternate years, while females matured at 24-26 and spawned at 4-6 year intervals. Diagrams described the difference between lake sturgeon

and Wisconsin's other acipenserid, the shovelnosed sturgeon. It was illegal to sell the flesh and roe of lake sturgeon in Wisconsin. PCBs in sediment where sturgeon fed were a fish and human health concern, as these fat soluble chemicals were easily absorbed and concentrated in the fat rich flesh of this fish. The state's Department of Natural Resources warned anglers not to eat PCB-contaminated sturgeon.

Meehan, W.E. 1909. Experiments in sturgeon culture. Trans. Am. Fish. Soc. 39: 85-91.

The report described early unsuccessful efforts to obtain ripe male and female shortnose sturgeon from the Delaware River, and to hatch sturgeon eggs. The relevance to lake sturgeon culture was discussed. Lake sturgeon eggs were lighter in colour than those of shortnose sturgeon. Efforts were underway to gather large lake sturgeon into ponds, as had been done with the shortnose species.

Meronek, K. 2004. A radio telemetry study of the movement patterns of lake sturgeon in the tailwater of White Rapids hydroelectric project, Menominee River, during May 2003. Final report to the Wilderness Shores Implementation Team. United States Fish and Wildlife Service, Green Bay Ecological Services Field Office, New Franken, WI. 22 p.

This document was not available for annotating.

Messier, D., and Roy, D. 1987. Concentrations en mercure chez les poissons au complexe hydroélectrique de La Grande Rivière (Québec). Nat. Can. (Qué.) 114: 357-368.

Mercury concentrations were analysed in 3,679 fish collected from the La Grande Complex between 1978 and 1984, and in 758 fish collected in 1985 from other Québec reservoirs and surrounding lakes. In the La Grande Complex, mercury concentrations rapidly increased in whitefish over the first four years of flooding. They then continued to increase, but at a lower rate. The increase in mercury in predatory species was gradual and was still progressing in 1984. Data from other reservoirs supported the hypothesis that maximum levels of mercury are reached between 2 and 7 or more years after flooding and then gradually decline over the next 20 years. Downward migrations through turbines and changes in feeding habits of usually non-predatory species

appeared to cause mercury levels to be 2-3 times higher in some species downstream of the hydroelectric structures as compared to those in the reservoirs.

Messier, D., Roy, D., and Lemire, R. 1985. Réseau de surveillance écologique du Complexe La Grande 1978-1984: Évolution du mercure dans la chair des poissons. Société d'énergie de la Baie James, Montréal, QC. xi + 170 p. + apps.

Hydroelectric development on the La Grande River involved the construction of three generating stations and the diversion of the Eastmain, Opinaca and Caniapiscau Rivers. The creation of reservoirs along the river flooded large areas of soil and vegetation and consequently increased the levels of mercury. Concerns about the effect of the development on the concentrations of mercury in the environment, including fish, prompted a study to determine concentrations before and after the creation of reservoirs. Fish sampling was done in 1978 and 1980, before the creation of reservoirs, and in 1981, 1982 and 1984, after the creation of reservoirs. Species sampled included walleye, northern pike, lake trout, burbot, lake whitefish, longnose sucker, lake cisco, brook trout and lake sturgeon. The creation of reservoirs along the La Grande River significantly increased the concentration of mercury in fish. The increase was rapid in the first few years in non-piscivorous fish while increases in mercury concentrations in piscivorous were more gradual. The rate of increase in mercury in fish was strongly correlated with the rate of decomposition of organic matter during the first years of the reservoir filling-up. Mercury concentration was two to three times higher in lake whitefish, longnose sucker and burbot tissue downstream from the La Grande 2 generating station relative to those fish from the reservoir. The higher concentration is thought to come from the transfer of prey from the reservoir and the change in feeding behaviour of species that are typically non-predatory. Fish from Lake Sakami were also higher in mercury and had values similar to fish from the Opinaca reservoir. Semi-anadromous fish from the estuary of the La Grande River had higher levels of mercury relative to samples taken in areas not affected by the development but were lower than fish from the reservoir of La Grande 2 generating station. The results demonstrated that riverine

and estuarine fish living downstream from generating stations have higher concentrations of mercury. The transfer of mercury in fish appeared to be the result of the ingestion of prey items. A program should be implemented in order to monitor mercury concentrations.

Meyer, A. 1933. Acanthocephala (concluded), p. 333-582. In Bronn's Klassen und Ordnungen des Tierreichs, 4 Abteilung 2, Buch 2, Lief 2.

Tanaorhampus ambiguus Van Cleave 1921 was described with *Anguilla chryspa* as the type host. In the host parasite list that followed on page 341, this parasite was listed under *Acipenser rubicundus* (lake sturgeon).

Meyers, L.S. 1982. Lake sturgeon population - upriver lakes (Poygan, Winneconne, Butte des Morts), 1979-1981. Wis. Dept. Nat. Res. Intra-departmental Memo. 7 p.

The lake sturgeon populations of the lakes mentioned in the title were sampled using gill nets during the fall seasons of 1979, 1980 and 1981. The objectives were to assess the population size of sturgeon ≥ 45 inches (legal size) and those under this size, movement of the fish, and tag retention. The catches for 1979, 1980 and 1981 were 152, 595, and 131 sturgeon, respectively. In all three years, the average size of the fish was 38 inches. The population estimates based on the 7.5-8 inch mesh gill nets were 9,059 for 1980 and 10,824 for 1981. However, since this mesh size did not adequately sample legal sized fish or fish under 30 inches, the population estimate was highly conservative. Management recommendations included the use of a variety of mesh sizes to sample the entire population and establishing a quota system on the upriver lakes.

Meyers, L.S. 1983. Lake sturgeon population - upriver lakes (Poygan, Winneconne, Butte des Morts), Winnebago County, 1982-1983. Wis. Dept. Nat. Res. Intra-departmental Memo. 8 p.

The lake sturgeon populations of the lakes mentioned in the title was sampled by 8-, 10-, 12- and 14- inch mesh gill-nets during October, 1982 and 1983. A total of 136 lake sturgeon were captured. The lengths ranged from 23-67 inches, with a binomial distribution. Nine of the fish were recaptures from tagging in 1979-1981. Based on the 8-inch gill net catch, the population size was estimated at 12,600. The lake sturgeon

population appeared to be increasing.

Michalenko, G., and Marcogliese, L. 1991. The subsistence lake sturgeon (*Acipenser fulvescens*) fishery of the Indian village of Muskrat Dam in northern Ontario, Canada, p. 447-458. In P. Williot (ed.) *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989. Bordeaux, France.

Biological data obtained from part of the 1988 lake sturgeon harvest were combined with fishing effort and location to describe the condition of the sturgeon fishery. Traditional knowledge and the use of sturgeon for domestic and community social functions were discussed.

Michalski, J. 2004. Lake sturgeon and the privatization of fish stocking. *The Creel* 37: 5.

This short article discussed a private fish farm in Minnesota where lake sturgeon were being raised and sold to the state for stocking. At writing, private culture of lake sturgeon in Wisconsin was forbidden.

Michigan State Board of Fish Commissioners. 1890. p. 44-46. In 9th Biennial Report. Lansing, MI.

This report introduced the lake sturgeon as once despised but now one of the most valuable fishes of the state's rivers and lakes. Sturgeon were taken principally by pound nets and set lines. The report recounted the first efforts of the board to artificially propagate this species, starting with experiments in the summer of 1889, at Algonac on the St. Claire River which was already the site of a caviar factory (Neilson & Co.). Milt from one male sturgeon was squeezed from the ripe gonads into a shallow (4 inch deep) tub and eggs allowed to run from females that were slit open and held over the tub. Half of the estimated 40,000 eggs were considered fertilized. Two days later a fungus appeared and spread rapidly over the incubating eggs. Hatching commenced from "good" eggs from day 9 onwards and on day 12, 8,000-12,000 hatched sturgeon were released into the river. The report also mentions, possibly the first successful artificial sturgeon culture experiments in the United States, in 1876, at New Hamburg on the Hudson River. Approximately 20,000

eggs were used and "140,000" sturgeon hatched. The latter number was obviously an error and should probably have been 14,000.

Michigan State Board of Fish Commissioners. 1895. Sturgeon, p. 28. In 11th Biennial Report. Lansing, MI.

Sturgeon hatching experiments of 1893 and 1894 were reported. During the 1893 season, 450,000 young sturgeon were hatched and released into the Detroit River. Hatching stations were set up at Michigan Central Railway Bridge and at Clarke's Point on the Detroit River. Set lines were used to capture sturgeon at the first station, and no running females were obtained. At Clarke's Point, where seine nets were used to capture sturgeon, running females were obtained, eggs of which were used in artificial propagation experiments resulting in the hatching and release of 130,000 fry that year. Methods of capture such as grappling caused ripe and running females to expel most of their eggs during the struggle for freedom. The subsequent relaxation allegedly allowed water to enter the vent rendering the remaining eggs infertile. Seining was recommended as the best method to secure running females for future artificial propagation experiments.

Michigan State Board of Fish Commissioners. 1899. Report of statistical agent, C. H. Moore, p. 22-34. In 13th Biennial Report. Lansing, MI.

This was a report on the commercial fisheries of Michigan during the 1896 and 1897 seasons. The lake sturgeon catches in Michigan waters declined from 831,606 pounds in 1891 to 184,881 pounds in 1897 (commercial value of \$9,640.19). During this period the sturgeon went from a fish of lowest market value to "one of the most profitable fish" in Michigan. This was attributed to the value of their cured and smoked flesh and of the caviar made from their roe. The common practice of capturing these fish by bottom set-lines and hooks was considered "barbarous", resulting in fatal and long-lasting injuries. The capture of sturgeon weighing as little as two pounds was, common in the state and "should not be tolerated". The tables following the text of the report provide details of the lake sturgeon yields by district. The total lake sturgeon yield for 1896 was 224,920 pounds worth \$9,965.56. The total caviar yield for 1896 was 38,399 pounds worth \$7,518.06 and for

1897 it was 44,119 pounds worth \$9,663.35. The report ended in a warning about the inevitable doom of commercial fisheries if immature fish were wantonly captured.

Migdalski, E.C. 1962. Lake sturgeon (*Acipenser fulvescens*), p. 92-96. In Angler's guide to the freshwater sport fishes of North America. Ronald Press Company, New York.

This general account of the biology and life history characteristics of the lake sturgeon provided anecdotal information from old-time sturgeon fishermen.

Miller, M.D., and Andrews, R.R. 1972. An investigation into the sport fishery of Nutimik Lake, summer 1968. Manit. Dept. Mines Res. Env. Manage. Res. Br. MS. Rep. 72-17: xi + 112 p.

During the summer of 1968, 784 anglers on Nutimik Lake, Manitoba were interviewed. The mean number of fish caught per angler-hour was 0.11. The catch consisted of sauger (56.2%), walleye (22.8%), lake sturgeon (9%), northern pike (7.5%), yellow perch (2.3%), burbot (0.8%), and smallmouth bass (0.8%). Water was analysed and benthic and gillnet sampling programs were conducted. The gillnet catch included mooneye (n = 229), whitefish (126), tullibees (105), walleye (79), white sucker (32), lake sturgeon (14), sauger (7), brook trout (4), northern pike (3), yellow perch (2), rock bass (2), and burbot (1). An economic analysis revealed that \$283,115 was spent on the Nutimik Lake sport fishery in the summer of 1968. The average angler spent \$38.84. The report compared this data with that from 1965.

Mingelbier, M., and J. Morin. 2005. Modélisation numérique 2 D de l'habitat des poissons du Saint-Laurent fluvial pour évaluer l'impact des changements climatiques et de la régularisation. Nat. Can. (Qué.) 129: 96-102.

Results are presented from a study of fish habitat in the St. Lawrence Seaway. A model was created using multivariate habitat data. The model produced the area of habitat available to species of fish under different water flow regimes. Lake sturgeon abundance was negatively correlated with depth and positively correlated with discharge rates. The model demonstrated the need for variable water flows

in order to satisfy habitat requirement for all fish species.

Mingelbier, M., Brodeur, P., and Morin, J. 2004. Impacts de la régularisation du débit des Grands Lacs et des changements climatiques sur l'habitat des poissons du fleuve Saint-Laurent. Vecteur Environ. 37: 34-43.

The purpose of this study was to evaluate the impacts of fluctuating water levels and flows on freshwater fish habitat caused by global warming and water regulation of Lake Ontario. The impacts were quantified for spawning habitats of fish that spawn in the spring, such as northern pike and yellow perch, and 10 species that spawn at the end of summer. A habitat suitability index (HIS) was created for four areas of the St. Lawrence Seaway using variables such as depth, vegetation and current speed. The HIS was examined with a two dimensional model to determine area of habitat at a given location during various flow regimes. High flow rates in the spring are beneficial for lotic species and negative for lentic species. Habitat for lake sturgeon was abundant during periods of high flows. The results demonstrated the need for annual variation in water flows to satisfy habitat requirements for all species in the St. Lawrence Seaway.

Mingelbier, M., Brodeur, P., and Morin, J. 2005. Recommendations concerning fish and their habitats in the fluvial St. Lawrence and evaluation of the regulation criteria for the Lake Ontario - St. Lawrence River system. Report presented to the International Joint Commission. Ministère des Ressources naturelles et de la Faune Québec, Direction de la recherche faunique, Québec. 141 p.

This document was not available for annotating.

Minnesota Department of Natural Resources. 2002. Restoration of extirpated lake sturgeon (*Acipenser fulvescens*) in the Red River of the north watershed. Minnesota Department of Natural Resources, Division of Fisheries. 10 p.

Lake sturgeon were extirpated from the Red River basin by the mid-1900s. Restoration sites chosen for lake sturgeon reintroduction included the Otter Tail, Rosseau, Red Lake and Buffalo rivers and Otter Tail, Round, White Earth and Detroit lakes. Each site was discussed and identified on an accompanying map. A 20-year

plan involving the stocking of fry and fingerlings from the Rainy River stock was proposed. The number of lake sturgeon stocked, life stage and frequency of stocking were provided for each restoration site. An ongoing evaluation plan for each site was summarized and the key issues of genetic suitability and barriers were discussed.

Minns, C.K., Brunette, P., Stoneman, M., Sherman, K., Craig, R., Portt, C., and Randall, R.G. 1999. Development of a fish habitat classification model for littoral areas of Severn Sound, Georgian Bay, a Great Lakes' area of concern. Can. Manuscr. Rep. Fish. Aquat. Sci. **2490**: ix + 86 p. + CD-ROM (Appendix F).

Lake sturgeon were listed as a coldwater non-piscivorous fish for Severn Sound, Georgian Bay.

Missouri Department of Conservation. 2000. Lake sturgeon, *Acipenser fulvescens*. [Fact sheet]. Best Management Practices. 1 p.

This short fact sheet discussed the ecology and distribution of lake sturgeon in Missouri. Reasons identified for the decline of lake sturgeon included over harvest, pollution, and restriction of movements due to dam construction. Recommendations included: 1) no alteration or removal of shallow rock and gravel in lake sturgeon areas; 2) no increases in siltation in preferred habitat; 3) prohibition of dams and other impoundments in large rivers and their tributaries; and 4) avoidance of channel alterations that will limit or remove shallow, sloping bank habitats.

Mohr, L.C. 1995. 1995 Lake Huron lake sturgeon assessment. Lake Huron Management Unit, Ontario Ministry of Natural Resources, Owen Sound, Ontario. 3 p. [Unpublished].

A summary of work conducted in 1995 was provided. Fifteen blood and tissue samples were collected from lake sturgeon in the North Channel and southern Lake Huron. At writing, results were unavailable. A total of 233 lake sturgeon were caught by commercial fishers in 1995. Of these, 103 were from southern Lake Huron and 114 from the North Channel. The largest sturgeon had a total length of 1.74 m and weighed 39.01 kg; the smallest had a total length of 0.235 m and weighed 0.1 kg. The depth at which sturgeon were caught averaged 6.5 to 7 m in spring, and 18 to 23 m in July and

August. Age was determined for 212 sturgeon, and ranged from 1+ to 37+ years. The mean age was 11 years. The male to female ratio was 4.25:1. Future programs were briefly discussed, including sampling of lake sturgeon spawning runs in the North Channel, a genetic sampling program, tagging of mature lake sturgeon (post spawning), a movement study, and a biological sampling program.

Mohr, L.C. 1997a. Characterization of lake sturgeon, *Acipenser fulvescens*, life history using digitized pectoral fin ray information, p. 456. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Mohr, L.C. 1997b. Summary of lake sturgeon assessment in Lake Huron, Ontario Waters, 1997. Ontario Ministry of Natural Resources, Lake Huron Management Unit, Owen Sound, Ontario. 3 p. [Unpublished].

In 1997, 617 lake sturgeon were caught and sampled by commercial fishers. This brought the total to 1,017 lake sturgeon sampled since 1995. The largest sturgeon taken in 1997, from the North Channel, had a total length of 1.77 m and a preliminary age of 30 years. The smallest, from Southern Lake Huron, weighed 0.1 kg and was 290 mm in total length and 1 year old. A total of 369 sturgeon were tagged in 1997. This brought the total number tagged in Lake Huron since 1995 up to 620 sturgeon. Projects for 1998 were listed.

Mohr, L.C. 1998. Summary of the 1997 activities of the Interbasin Lake Sturgeon Working Group in waters of Lakes Huron, St. Clair, and Erie. J.R. McClain (ed.) United States Fish and Wildlife Service, Alpena Fishery Resource Office, Alpena, Michigan. Pagination unknown.

The work completed in 1997 was a continuation of the two previous years; no new projects were initiated. A total of 617 lake sturgeon were sampled in 1997, 484 from southern Lake Huron, 132 from the North Channel, and one from northern Lake Huron. Thirty of these fish were had been tagged the previous year. A total of 1,017 had been sampled and tagged in Ontario waters. The modal size of all fish sampled was just over 1 m, but heavily biased

by the legal size available to commercial fishermen. The smallest sturgeon sampled was from southern Lake Huron and measured 290 mm in total length and weighed 0.1 kg. The largest lake sturgeon sampled was 1.77 m in total length and was an estimated 30 years old.

Mohr, L.C. 2000. Lake sturgeon monitoring in Ontario waters of Lake Huron - 2000. Ontario Ministry of Natural Resources. Upper Great Lakes Management Unit, Lake Huron Office. 5 p. [Unpublished].

A total of 648 lake sturgeon were captured and sampled by commercial fishers in 2000. Most of these fish (65%) were captured in the extreme southern area of the Main Basin. Of the sturgeon sampled, 365 were tagged and released and 39 were recaptures tagged in previous years. The mean total length of sturgeon sampled in 2000 was 1,067 mm (range 335-1,950 mm); the mean round weight was 9.01 kg (range 0.125-46.2 kg), and mean age was 13.2 years (range 2-42 y). Mean size and age data were also given by area sampled (Main Basin, Georgian Bay, North Channel and Mississauga River). The age distribution was likely biased by gear type and the fact that most sturgeon were caught incidentally. The results from 2000 were compared with those from previous years.

Mohr, L.C. 2002. Lake Huron (Georgian Bay and the North Channel) sturgeon assessment update 2002. Ontario Ministry of Natural Resources. Upper Great Lakes Management Unit, Lake Huron Office. 4 p.

A total of 565 lake sturgeon were caught by commercial fishers in 2002. Of these, 462 were from the Main Basin, 48 from the North Channel and 58 from Georgian Bay. The largest lake sturgeon had a total length of 1,821 mm, with a girth of 802 mm and a weight of 44.45 kg. The average total length was 1079 mm and the average girth was 411 mm. A total of 321 lake sturgeon were tagged. Ages were determined for 509 lake sturgeon, revealing 39 age groups with most falling in the 6, 11, and 16 year age classes. The average age was 11.8 years. Genetic analysis of spawners, tagging with temperature/depth tags and the investigation of non-lethal tissue sampling techniques were also discussed.

Mohr, L.C., and McClain, J.R. 2001. Lake sturgeon (*Acipenser fulvescens*) in Lake Huron, past, present, and future, p. 95. In Abstracts from the 44th Conference on Great Lakes Research, June 10-14, 2001. Great Lakes science: making it relevant. [Abstract only].

Traditional lake sturgeon fisheries once existed in the large tributaries of the North Channel, eastern Georgian Bay, and Saginaw Bay. A commercial fishery began in the 1860s, and peaked in the 1880s. Sturgeon harvests declined sharply thereafter and have remained low. Commercial harvest had not changed in the last 60 years and there was limited recreational exploitation. The recovery of the lake sturgeon population appears to have been limited by access to spawning grounds and poor juvenile habitat.

Moisan, M., and Laflamme, H. 1999. Rapport sur la situation de l'esturgeon jaune (*Acipenser fulvescens*) au Québec. Faune et Parcs Québec, Direction de la faune et des habitats, Québec. xi + 68 p. Available from http://recitmst.qc.ca/fapaq/parc/IMG/pdf/esturgeon_jaune_rapport.pdf [accessed 5 April 2006].

This report summarized information from past studies in order to describe the biology, ecology, habitat, population, limiting factors, value and conservation of lake sturgeon in Québec. Lake sturgeon were an important commercial species, with 200-250 tonnes harvested each year in the St. Lawrence Seaway and other smaller nearby lakes with a gross value in excess of \$750,000. Measures to prevent overexploitation of lake sturgeon stocks were implemented in 1980 and included shorter commercial fishing seasons, the banning of longlining, smaller mesh sizes, decreased number of permits and the closing of the commercial fishery at Saint-François Lake. Other closures included the lower Outaouais, Bell, Mégiscane, Guéguen, Harricana and Baskatong Rivers. Recent management plans have implemented a fixed fishing season for the whole year, gill net mesh sizes between 19 and 20.3 cm in rivers and 22.9 and 25.4 cm elsewhere, fish size restrictions, limitation on the number of nets in an area, and quotas in some locations. The St. Lawrence Seaway population is dependent on the spawning ground in the des-Prairies River which is located in the middle of an urban setting. The most threatening factors for lake sturgeon in Québec were commercial exploitation, poaching, loss of critical habitat,

hydroelectric development and pollution.

Mokhayer, B. 1981. Parasites des poissons du bassin de Sefid-Roude. J. Vet. Fac. Univ. Tehran 36: 59-75.

The parasites of *Acipenser gueldenstaedti* from the Sefid-Roude Basin of the Caspian Sea drainage system were listed. *Polypodium hydriforme* was found in the eggs.

Mongeau, J.-R. 1979. Recensement des poissons du lac Saint-François comtés de Huntingdon et Vaudreuil-Soulanges, pêche sportive et commerciale, ensemencements de maskinongés, 1963 à 1977. [Québec] Ministère du Tourisme, de la Chasse et de Pêche. Service de l'Aménagement et de l'Exploitation de la Faune, District de Montréal Report 06-25: 125 p.

Results from a survey of fish species in Saint François Lake were discussed. Data was compiled from experimental gill netting and seining, and catch data from recreational and commercial fishing. A total of 42 species were recorded of which perch was the most abundant species captured in experimental gill nets. Lake sturgeon made up a small proportion of the catch representing 0.12% of the total. It was the most important species of the commercial fishery with 20,081.4 kg harvested in 1970 and 1972-77 worth \$47,990. Stricter size limits for lake sturgeon were proposed.

Mongeau, J.-R., Leclerc, J., and Brisebois, J. 1982. La dynamique de la reconstitution des populations de l'esturgeon jaune *Acipenser fulvescens* du Lac des Deux Montagnes, Province de Québec, de 1964 à 1979. Rapp. Tech. Québec Minist. Loisir Chasse Pêche. 6-33: 194 p.

A series of lake sturgeon population studies were undertaken in Deux Montagnes Lake, Québec, in 1964-66, 1968-69 and 1978-79. Fish were captured using experimental gill nets and measured, weighed, tagged and released for mark recapture purposes. Fin clips were taken for aging. Some lake sturgeon were sacrificed for gonad and stomach content analysis. No fish born prior to 1954 were captured, four years after a large winter-kill of fish in the lake in 1950. It was concluded that recruitment of juveniles was irregular due to variable spawning periods with only seven spawning events recorded between 1950 and 1979. A small proportion of

mature fish was likely the reason for the irregular spawning pattern. A total of 4,571 fish were collected and results from the mark-recapture study indicated that movement was strongly localized as 90% of lake sturgeon were recaptured within the same general area. The average length of fish had an increasing trend in the early years of the study although later sampling resulted in somewhat smaller and more variable size estimates. Size limits are proposed for lake sturgeon. A quota adjustment, a closed fishing season and implementation of a commercial gill net mesh size greater than 30 cm were also recommended.

Moore, J.P. 1924. The leeches (Hirudinea) of Lake Nipigon. Univ. Toronto Stud. Biol. 25: 17-31 (Ont. Fish Res. Lab. Publ. 23).

Macrobdella decora was reported from lake sturgeon in Ontario for the first time.

Moreau, D.A., and Parrish, D.L. 1994. A study of the feasibility of restoring lake sturgeon to Lake Champlain. Lake Champlain Basin Program [Grand Isle, VT] Tech. Rep. No. 9: 104 p.

A stocking program was proposed based on life history information, ecological requirements, availability of suitable habitat, and a sturgeon population model. The authors recommended stocking Lake Champlain with 10,000 age-1 lake sturgeon annually for 10 years, after which time a population assessment would be conducted. They recommended that stocking continue after the 10 year mark to reduce the amount of time needed for a stable population to be reached from 250 years to 60 years. Because of the risk of exceeding carrying capacity, 10,000 individuals would continue being stocked if juvenile survival was <0.1, but if juvenile survival was >0.1, only 5,000 would be stocked. If after 20 years there was evidence of spawning, only 5,000 would be stocked per year. If there was no evidence of spawning or mortality rates were high at any point in the stocking program, studies would be initiated to investigate these problems.

Moreau, G., and Legendre, L. 1979. Relation entre habitat et peuplements de poissons: essai de définition d'une méthode numérique pour des rivières nordiques. Hydrobiologia 67: 81-87.

This paper described the relationships between various species of fish in the downstream sections of the Nottaway, Broadback and Rupert rivers of northern Québec. A total of 18 species of fish were identified, of which 11 were not abundant. Six types of habitat were identified by linkage clustering based on physical characterization of 163 sampling locations. This was followed by a multiple discriminant analysis between the six habitat types and abundances of the different species. Three species, namely, lake sturgeon, pike and walleye (pickerel), were characteristic of the second discriminant function (second axis) which was dependent upon the interaction between current velocity and vegetation abundance.

Moreau, R.F. 1999. Studies on ascorbic acid biosynthesis in fish, effects of antioxidant vitamins on L-gulonolactone oxidase activity. Diss. Abstr. Int. B Sci. Eng. **60**: 1943.

Teleost fish lacked the enzyme L-gulonolactone oxidase; all non-teleost fishes studied had the enzyme in the kidney. It appeared that kidneys were the site of ascorbic acid synthesis in poikilothermic vertebrates. The ability to synthesize ascorbic acid may have originated from ancestors 590-500 million years ago. A 1 kg sturgeon could synthesize 3 mg ascorbic acid per day at 15°C. Feeding sturgeon with high levels of vitamin C did not slow down the rate of synthesis and stimulated enzyme activity. Deprivation of either vitamin C or E did not affect L-gulonolactone oxidase activity.

Moreau, R.F., and Dabrowski, K. 1996. Feeding stimulants in semipurified diets for juvenile lake sturgeon, *Acipenser fulvescens* Rafinesque. Aquac. Res. **27**: 953-957.

Betaine, krill, and fish protein concentrate were tested for their palatability in diets of juvenile lake sturgeon. Diets were formulated to contain at least 40% crude protein and 12% crude fat. The five thousand larvae obtained were initially fed nauplii of brine shrimp and reared on sturgeon starter diet to the body weight of 1 to 5 g. Water temperature was $19.2 \pm 0.6^\circ\text{C}$ throughout the experiment. A detailed table provided the composition of the 5 experimental diets, and in another table the growth and survival of juvenile lake sturgeon of two different sizes were shown. The impacts of different diets on sturgeon behavior and physical characteristics were discussed.

Moreau, R., and Dabrowski, K. 1997. Vitamin C - vitamin E interaction in juvenile lake sturgeon (*Acipenser fulvescens* R.). In Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

Moreau, R., and Dabrowski, K. 2000. Biosynthesis of ascorbic acid by extant actinopterygians. J. Fish Biol. **57**: 733-745.

Several fish species were analyzed in this study. Antibodies directed against white sturgeon gulonolactone oxidase exhibited cross-reactivity with lake sturgeon enzymes. Gulonolactone oxidase relatedness matched actinopterygian phylogeny and suggested the homology of the feature throughout fishes. Modern teleosts may have lost the ability to synthesize ascorbic acid because of a single reversal in the founding population from the late Triassic.

Moreau, R.F., Dabrowski, K., Czesny, S., and Chila, F. 1999. Vitamin C - vitamin E interaction in juvenile lake sturgeon (*Acipenser fulvescens* R.), a fish able to synthesize ascorbic acid. J. Appl. Ichthyol. **15**: 250-257.

Ten-month-old lake sturgeon were fed diets supplemented with 0 or 1,250 mg ascorbic acid/kg in conjunction with 0 or 200 mg α -tocopherol/kg for 7 weeks at 17°C to determine if vitamin C interacted with vitamin E *in vivo*. Results showed that the dietary vitamin C supplement resulted in significant increases of ascorbate concentrations in the posterior kidney and liver of sturgeon. Omission of dietary vitamin E affected liver concentrations of α -tocopherol in comparison to sturgeon fed a diet supplemented with vitamins E and C. Dietary vitamin C supplement decreased liver α -tocopherol concentration in sturgeon deprived of vitamin E. The vitamin E supplement lowered posterior kidney and liver ascorbic acid concentrations in those fish deprived of vitamin C. Gulonolactone oxidase and dehydroascorbic acid reductase activities were stimulated in groups fed vitamin C. Thiobarbituric acid-reactive substances showed higher concentrations in sturgeon fed either vitamin when compared to those fed neither. Results implied that large doses of vitamins C and E may be prooxidant *in vivo*.

Moreau, R.F., Dabrowski, K., and Sato, P.H. 1999. Renal L-gulonolactone oxidase activity as affected by dietary ascorbic acid in lake sturgeon (*Acipenser fulvescens*). *Aquaculture* **180**: 359-372.

The effect of increasing dietary ascorbic acid on gulonolactone oxidase activity was studied. Two-year-old lake sturgeon were fed casein-based semipurified diets in triplicate groups, supplemented with either 0, 50, 250 or 1,250 mg ascorbic acid/kg (ascorbyl-2-monophosphate Mg) for 38 days at a temperature of 19.8°C. Although there was no significant difference in growth rate among the groups, total ascorbic acid concentrations in tissue increased significantly with dietary treatment. These results revealed that dietary ascorbic acid did not cause a negative feedback control on gulonolactone oxidase activity and the ascorbic acid synthesized. A theoretical biosynthetic rate of ascorbic acid of 17 µmol per kilogram body weight per day at 15°C in juvenile lake sturgeon was estimated.

Morin, G. 2001. Translation of Elder interviews on Sturgeon-Sandy Bay and Pelican Narrows, May-July, 2001. 22 p.

The seven interviews translated in this document were conducted as part of a traditional knowledge review of the status of lake sturgeon on the Churchill River, Saskatchewan. The preliminary findings include a general agreement among the Elders that lake sturgeon are in decline and that this decline started when a hydroelectric facility was built in the area in 1930. Information gaps are present due to the interviewer not knowing the appropriate questions to ask, so a second set of interviews was recommended.

Morse, S.D., Weaver, H.T., Linder, A.T., and Hugill, R.A. 1997. Habitat suitability curves for lake sturgeon based on radio-telemetry observations in the Kettle River, Minnesota. Completion report. Minnesota Department of Natural Resources, Hinckley. Fish and Wildlife Restoration Program, Washington, D.C. 46 p.

A radio-telemetry study was undertaken in Kettle River, Minnesota. The resulting data was used to create substrate, depth, and velocity preference histograms, and depth and velocity suitability curves. Three 24-hour tracking studies were completed and day and night

preference histograms and suitability curves were developed. Sand was the preferred substrate. Differences between day and night substrate preferences were minimal. Preferred depth increased as deeper water became available.

Mosindy, T. 1987. The lake sturgeon (*Acipenser fulvescens*) fishery of Lake of the Woods, Ontario, p. 48-56. In C. H. Olver (ed.) Proceedings of a Workshop on the Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. **23**.

The collapse of the lake sturgeon fishery in the Lake of the Woods was reviewed. There were no gear restrictions by the U.S. fishery, other than prohibiting gill nets, until 1895. Thereafter, regulations restricted the licensee to a maximum of 50 pound nets, which decreased to six per licensee in 1925. The Canadian fishery was restricted from the start to one pound net and 914 m of gill net per license holder. Within one decade (1893-1903), the sturgeon catch declined by 95%, and by 1930 the fishery was virtually non-existent. Overfishing was the major reason for the collapse. Mismanagement was evident on both sides of the border. During the peak of the catch in the beginning of this century, a recommendation by the International Fisheries Commission to curtail all sturgeon fishing for four years to allow stocks to rebuild was not implemented. The lack of minimum size regulations left immature sturgeon unprotected and the decline in caviar production reflected the loss of mature fish from the population. The pulp and paper industry and the construction of a hydroelectric dam at the outlet of Rainy Lake (Rainy River) proved disastrous to any chances the remaining sturgeon population might have had to recover. Waste effluent from the mills contributed to the documented decline of at least two other fish species in the region (walleye and longnose sucker), and to the loss of prime sturgeon spawning grounds. Problems were compounded by agricultural development which increased runoffs into natural waterways. A sturgeon fishery still existed in one part of the lake, with the majority of the catch coming from fishing lots 47 and 57 and from a native fishery at Manitou Rapids. At writing, gill nets were the only gear in use, and licensed sturgeon fishers were restricted to a maximum of 1,850 m of net and a minimum dressed length of 58 cm. Since 1984, the total annual sturgeon quota for the Ontario part of the lake had been 4,545 kg and

the Rainy River fishery had had an annual quota of 1,275 kg. The reduction of effluent from the paper industry appeared to have improved reproductive success, as evidenced by an increase in the number of younger fish caught. Compared to other populations in northern Ontario, the Lake of the Woods population seemed to be faster growing. The age of sexual maturity for this population remained unknown.

Mosindy, T., and Marshall, T. Date unknown. Evaluation of various size regulations to manage border waters lake sturgeon. Northwest Science and Technology, Ontario Ministry of Natural Resources, Kenora and Thunder Bay, Ontario. 18 p.

This document detailed the results of a modeling workshop conducted to determine if changes to size regulations might assist lake sturgeon recovery in Ontario-Minnesota border waters and still allow for exploitation. The impacts of current size regulations on lake sturgeon in Lake of the Woods and Rainy River were also examined. The current minimum size limit in these waters was 127 cm (50 inches). Minimum size regulations had been ineffective in curbing the decline of lake sturgeon populations caused by overexploitation. Alternative methods, such as the use of harvest slot sizes (currently being investigated in the Pacific U.S. states for white sturgeon) were discussed. All model simulations were run on the Fisheries Management Support System (FMSS). Inputs to the model and results were detailed. The authors concluded that a 114-140 cm harvest slot regulation would be most effective for protecting female spawners and maintaining adult abundance at increased levels of angling effort. Limitations of the model were discussed.

Mosindy, T., and Rusak, J. 1991. An assessment of lake sturgeon populations in Lake of the Woods and the Rainy River 1987-1990. Ministry of Natural Resources. Lake of the Woods Fisheries Assessment Unit Report 1991:01: viii + 59 p.

The history of commercial and subsistence fishing, as well as causes of the rapid decline of lake sturgeon populations in the Rainy River and Lake of the Woods were discussed. The objective of this study was to assess the current status of lake sturgeon in the area and recover information crucial to formulate a management plan. Lake sturgeon inhabiting the study area

appeared to be from two populations differentiated by their winter habitat use and timing and patterns of spawning. Spawning habitat did not appear to be limited to this area, but the quality of sites along the Rainy River were directly affected by fluctuating river flows and the presence of accumulations of attached algae and silt on the substrate. The best quality habitat was thought to be in the larger tributaries flowing from Minnesota. Age and size frequency distribution showed that these were relatively young populations. Growth rates were compared between locations. Annual mortality rates were estimated for the two populations, ranging from 0.153 to 0.185 throughout the years of study, and were found to be relatively high when compared to other populations. Spawning and recruitment were occurring successfully on an annual basis. Age-at-first maturity was 16.8 years for males and 25.8 years for females. Spawning periodicity was similar to other populations throughout the range of lake sturgeon. The authors concluded that commercial fishing at its current level was sustainable in the study area.

Nash, C.W. 1908. Order Chondrostei (the sturgeons), p. 13-14. *In* Vertebrates of Ontario. Department of Education, Toronto, ON.

The lake sturgeon was briefly described with a short note on its distribution and biology. The commonly held view by fishermen that two forms of the freshwater sturgeon existed was attributed to age-related morphological differences among individuals and it was affirmed that only one species, the lake sturgeon, occurred in Ontario waters. The species was said to spawn from the end of May to the beginning of July.

Natchez Animal Supply Company. (Sponsor) 2002. Freedom of information summary: NADA 137-687, Formalin-F™. Supplemental New Animal Drug Application. 16 p. Available from <http://www.fda.gov/cvm/FOI/137-687.pdf> [accessed 5 April 2006].

This study examined whether Formalin-F™ could be used as a parasiticide for all finfish and penaeid shrimp, and as a fungicide for the eggs of all finfish. Formalin was added to water in concentrations of 1,500, 4,500 and 7,500 ppm. It was safe for lake sturgeon at a concentration of 1,500 ppm or less for up to 15 minutes daily.

National Marine Fisheries Service. 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. vii + 104 p.

Topics covered in this recovery plan included nomenclature and taxonomy, population status, biological characteristics, factors affecting recovery, recovery, and an implementation schedule. Biological characteristics included habitat and life history, reproduction, growth, survival and recruitment, migration and movements, feeding, and predators, parasites and diseases. The section on recovery consisted of a recovery strategy, a recovery outline, a recovery narrative and a recovery task summary. The recovery outline included three primary steps. The first was to establish listing criteria. This involved determining the size of shortnose sturgeon population segments for listing and evaluating trends in recruitment, determining the minimum habitat for population segments, and determining the maximum allowable mortality for population segments. The second step was to protect shortnose sturgeon populations and habitats. This involved ensuring agency compliance with the *Endangered Species Act*, reducing bycatch, determining if critical habitat designations are needed, mitigating or eliminating negative anthropogenic impacts, designing a public education program, and coordinating all levels of government and private recovery efforts. The third step was to rehabilitate habitats and population segments. This final step involved the restoration of habitats and their functions in the life histories of each population segment, the development of a breeding and stocking protocol, the reintroduction of shortnose sturgeon into rivers where they have been extirpated and an assessment of the need for additional stocking. Lake sturgeon were not discussed, but this document does provide an example of a sturgeon recovery plan.

Ndayibagira, A., Cloutier, M., Anderson, P.D., and Spear, P.A. 1995. Effects of 3, 3', 4, 4'-tetrachlorobiphenyl on the dynamics of vitamin A in brook trout (*Salvelinus fontinalis*) and intestinal retinoid concentrations in lake sturgeon (*Acipenser fulvescens*). *Can. J. Fish. Aquat. Sci.* 52: 512-520.

Field validation of the effects on intestinal

retinoids was conducted with lake sturgeon caught at a contaminated site near the origin of the Ottawa River. Intestinal retinoid concentrations were lower (RP, $p < 0.0008$; DRP, $p > 0.0004$) in the St Lawrence River sturgeon than in the adult brook trout treated with a single injection of 5 μg 3, 3', 4, 4' tetrachlorobiphenyl. Coplanar PCB was capable of altering vitamin A dynamics in tissues and organs and may have caused lower concentrations of retinoids in the intestines.

Nechat, H.A., and Mokhayer, B. 1974. Parasites de l'appareil génital des esturgeons. *Rev. Med. Vet.* 125: 355-360.

One hundred and seventy-one sturgeon belonging to three species, and caught from seven fishing stations on the Iranian side of the Caspian Sea, were examined for parasites. A low percentage of the eggs of *Acipenser stellatus* from the Sefidroude stream were infected with *Polypodium hydriforme*. The infected eggs, 5.5-7.7 mm in diameter, were two to three times the size of the normal eggs. The parasite within the eggs measured 1.605 x 0.100-0.370 mm. The low intensity of infection, compared to that in *Acipenser ruthenus* (reported by Raikova, 1958), was explained by the fact that infection could take place only during the time that this sturgeon moved through the rivers during spring and autumn. Hence, parasitism by *Polypodium* was accidental and took place in those individuals that departed late in the spring and arrived early during the fall. The pathological effect of this parasite was manifested in the destruction of infected eggs.

Nelson, J.S., and Paetz, M.J. 1992. Sturgeon family — *Acipenseridae*, p. 97-102. *In* The Fishes of Alberta, 2nd Edition. The University of Calgary Press and the University of Alberta Press, Canada.

The distribution and general morphological characteristics of lake sturgeon were discussed. Characteristics described included colour, size, life history, and distribution within Alberta.

Niblett Environmental Associates Inc. 1988. Proposed Carmichael Falls hydroelectric development: environmental appraisal. Prepared for Wm. R. Walker Engineering Inc., Sault Ste. Marie, ON. 50 p.

This document was not available for annotating.

Niblett Environmental Associates Inc. 1989. Carmichael Falls hydroelectric development - environmental appraisal. Bethany, ON. Pagination unknown.

This document was not available for annotating.

Niblett Environmental Associates Inc. 1992. Carmichael Falls hydroelectric project: year 1 of a long term monitoring program. Bethany, ON. Pagination unknown.

This document was not available for annotating.

Niblett Environmental Associates Inc. 1993. Carmichael Falls hydroelectric project. Year II of a long term monitoring program. Prepared for Algonquin Power Corp. Inc., Oakville, ON. 58 p.

This document was not available for annotating.

Nichols, S.J., Kennedy, G., Crawford, E., Allen, J., French, J., Black, G., Blouin, M., Hickey, J., Chernyak, S., Haas, R., and Thomas, M. 2003. Assessment of lake sturgeon (*Acipenser fulvescens*) spawning efforts in the lower St. Clair River, Michigan. J. Gt. Lakes Res. 29: 383-391.

The impacts of the recent colonization of the St. Clair River by round gobies (*Neogobius melanostomus*) on the reproductive success of lake sturgeon were investigated. While gobies did prey upon sturgeon eggs and larvae, other factors also affected sturgeon reproduction, including the presence of few spawning adults, poaching pressure, low retention of eggs on the St. Clair River delta, low hatching rates, organic contaminants, and predation by native and exotic invertebrates and fish. Less than 1% of the eggs deposited survived to hatch, but by placing eggs in predator exclusion chambers on the delta reef, the authors were able to increase the egg hatch rate to 16%. However, two weeks after hatching no larvae were found anywhere in the river. Because of a high silt load in 1999, large numbers of dead larvae were found in the river that year. Management recommendations such as reducing the illegal harvesting of adult fish and placing eggs in predator-exclusion chambers may increase the chances for sturgeon survival.

Nieuwenhuys, R. 1974. Topological analysis of the brain stem: a general introduction. J. Comp. Neurol. 156: 255-276.

This paper discussed the protocol for a project to analyze the brain stems of 12 representative vertebrates using the topological method. The lake sturgeon was chosen as a representative of the chondrosteans. The article started with a review of the literature of brain stem anatomy. Due to the arrangement of the stem into longitudinal columns, the actual number, cellular content and organization and delimitation of these zones were difficult to follow in cross-section. Consequently the author introduced the procedure of topological analysis (expounded in an earlier paper) to resolve problems in three dimensional interpretation of the anatomy. It was proposed that the brain stems of each of these species would be subjected to the analysis and the results compared for similarities and phylogenetic affinities.

Nilo, P. 1996. Force des classes d'âge, habitats et alimentation des sturgeons jaunes (*Acipenser fulvescens*) juvéniles du système Saint-Laurent. Mémoire présenté comme exigence partielle de la maîtrise en biologie. Université du Québec à Montréal. ix + 86 p. + apps.

Experimental gill netting was done in four sections of the St. Lawrence Seaway and the des-Prairies and Assomptions rivers between 1991 and 1993 in order to evaluate lake sturgeon recruitment. Over 1,000 lake sturgeon were captured, had a section of pectoral fin removed for aging purposes, and returned back to the water. Year class strength was highly correlated with increasing water temperatures in May and June and with water flows at the generating station at the des-Prairies River in June. Results suggested that year class strength was established early in the first year, and that the thermal and hydrologic conditions during spawning, and larval hatching and feeding were important factors for recruitment. Juvenile habitat was also characterized. Canonical correspondence analysis indicated that water speed and depth were the most important variables determining distribution. In the fall, lake sturgeon were found in 3.1-6 m deep water with velocities between 0.25 and 0.5 m/s. In the summer, the fish were found in deeper and faster waters. Lavage of the stomach was done in order to determine and quantify prey items. Less food was observed in stomachs in August and September, potentially due to increased water temperatures. The most important prey species were crustaceans, insect larvae, molluscs, annelids and fish. Most potential prey

found in an area was underutilized by lake sturgeon except for gammarids, ephemeroptera and trichoptera.

Nilo, P. and Fortin, R. 1994. Caractérisation de l'habitat des juvéniles et évaluation de la force des classes d'âge de l'esturgeon jaune (*Acipenser fulvescens*) dans le secteur du fleuve Saint-Laurent compris entre Montréal et Sorel. Ministère de l'Environnement et de la Faune, Québec. Rapport final, nov. 1994. vii + 71 p.

The objective of this study was to quantify and characterize juvenile lake sturgeon habitat in order to improve management. Studies began in 1991 in the St. Lawrence River between Montréal and Sorel, and were continued in 1992 and 1993 with the addition of sites at Verchères Island. Lake sturgeon were captured using gill nets and environmental variables were recorded for multivariate analysis. The autumn distribution of lake sturgeon was limited by current speed and depth. Lake sturgeon and walleye were closely associated in the fall in shallow areas sheltered from strong currents. Year class strength was assessed for three sites: Des Prairies and Assomption Rivers and Sorel-Berthier Island. It was highly correlated with daily increases in water temperature in May and June, and discharge in June at Carillon. The authors concluded that recruitment was highly dependant on environmental conditions during spawning and in the initial life history stages.

Nilo, P., Dumont, P., and Fortin, R. 1997. Climatic and hydrological determinants of year-class strength of St. Lawrence River lake sturgeon (*Acipenser fulvescens*). Can. J. Fish. Aquat. Sci. **54**: 774-780.

Year-class strength and age structure were determined from lake sturgeon caught in the St. Lawrence River and two of its tributaries (Des Prairies and L'Assomption rivers) using gillnets. A ratio of 1:7 was observed between the weakest and the strongest year-classes, 1980 and 1989, respectively. There were significant positive correlations between year-class strength and daily rate of increase in St. Lawrence River water temperature in May and June, and mean June water flows in the Des Prairies River. Year-class strength could be determined in the first few months of life. Climatic and hydrologic conditions in June were critical determinants of year-class strength in the St. Lawrence River lake sturgeon.

Nilo, P., Tremblay, S., Bolon, A., Dodson, J., Dumont, P., and Fortin, R. 2006. Feeding ecology of juvenile lake sturgeon in the St. Lawrence River system. Trans. Am. Fish. Soc. **135**: 1044-1055.

Diet was examined at 5 sites in the St. Lawrence River system, including Des Prairies and L'Assomption rivers, Verchères and Sorel-Berthier islands, and the estuarine transition zone (ETZ) of the St. Lawrence River. Seventy-four invertebrate prey taxa were identified, and approximately 50 of these occurred in more than 5% of stomachs. The same sampling strategy and techniques were used at three of the sites. Diet varied significantly between these sites and by the month sampled. Diet also varied significantly with fish length, independent of month and site. Diet was dominated by amphipods at all sites except the L'Assomption River, where chironomids dominated. Other important prey included oligochaetes, ephemeropteran nymphs, trichopteran larvae, molluscs, and fish eggs. The highest diet diversity was found in juveniles from the Verchères Islands, while those in the ETZ had the lowest. Aside from confirming that lake sturgeon are generalists and opportunistic benthic feeders, this study also showed that diet is only partly determined by prey availability, and that juveniles may positively select for drifting prey.

Noakes, D.L.G., Beamish, F.W.H., and Rossiter, A. 1999. Conservation implications of behaviour and growth of the lake sturgeon, *Acipenser fulvescens*, in northern Ontario. Environ. Biol. Fishes **55**: 135-144.

Age and size distribution were examined for lake sturgeon in the Groundhog and Mattagami rivers in northern Ontario, Canada. Age was determined from counts of annuli in pectoral fin rays. Ages ($n = 327$) ranged from 1 to 69 years. Growth was calculated from a von Bertalanffy growth equation and expressed as an increase in fork length. It slowed from a peak of 3.9 cm per year during the juvenile period (<9 years) and approached an asymptote beyond 90 years. A length-mass equation and conversion factors for fork length and total length ranged from 14.5 cm to 142 cm (fork length), 15.5 cm to 15 cm (total length) and 20 g to 19,730 g (live mass) for 1,177 fish. There was no evidence for spawning

or recruitment in the population. Final analysis revealed that age and length structure were strongly bimodal, and the growth rate had slowed during the past 10 years.

North Central Power Co., Inc. 2000. Application for new license minor water power project existing dam, FERC project no. 2064 - Wisconsin. Volume II (Supplement). Appendices: E.3(a) fishery survey of reservoir area. North Central Power Co., Inc. 34 p.

This document was not available for annotating.

North Saskatchewan Watershed Alliance. 2005. State of the North Saskatchewan Watershed Report 2005 - A Foundation for Collaborative Watershed Management. North Saskatchewan Watershed Alliance, Edmonton, Alberta. 202 p. Available from <http://www.nswa.ab.ca/pdfs/sowr.pdf> [accessed 5 April 2006].

This report discussed the state of the North Saskatchewan Watershed within Alberta. Lake sturgeon were listed as occasionally occurring in the North Saskatchewan River of the Strawberry Subwatershed. A systematic study of fish species in the North Saskatchewan Watershed had not yet been completed.

North Shore Environmental Services (NSES). 1993. Summary of predevelopment monitoring information collected, October 1993, proposed Long Sault Rapids hydrosite. Prepared for N.R. Power and Energy Corp., Cambridge, ON. Pagination unknown.

This document was not available for annotating.

North/South Consultants Inc. 2002. Saskatchewan River Sturgeon Management Board ten-year management plan. Prepared for the Saskatchewan River Sturgeon Management Board by North/South Consultants Inc., Winnipeg, MB. xi + 88 p. + maps.

The short-term objective of this management plan was "To prevent further decline of the Saskatchewan River lake sturgeon population between the E.B. Campbell Dam and Grand Rapids Dam" (pg. iii). The long-term objective was "To have a Saskatchewan River lake sturgeon population between E.B. Campbell Dam and Grand Rapids Dam that is self-sustaining, and capable of supporting the

traditional uses of local Aboriginal people" (pg. iii). Goals included stabilizing the existing spawning population over the next five years, achieving an increase in the lake sturgeon spawning population within twenty years, obtaining community support for voluntary actions that ensure sustainable harvest levels, and determining the long-term objective and the most effective way to meet it within the next five years. Management strategies included monitoring, increasing recruitment, decreasing mortality, public education and habitat assessment. Each goal and management strategy was discussed in detail. This document also examined lake sturgeon life history, provided an historical overview of Saskatchewan River lake sturgeon and summarized current knowledge.

North/South Consultants Inc. 2003. Saskatchewan River lake sturgeon harvest surveys 2001-2002. Prepared for Saskatchewan River Sturgeon Management Board by North/South Consultants Inc., Winnipeg, MB. vii + 42 p.

Creel interviews were conducted at The Pas, Manitoba and Cumberland House, Saskatchewan to determine the number of lake sturgeon harvested from the Saskatchewan River between the Manitoba/Saskatchewan border and the mouth of the Summerberry River, Manitoba. A total of 365 fishers were interviewed at The Pas in 2001. They reported catching a total of 62 lake sturgeon, of which 57 were kept. Length- and weight-frequency distributions were presented. A total of 329 fish of other species, mainly walleye and northern pike, were also reported. The estimated total harvest of lake sturgeon at The Pas in 2001 was 302. A survey of Opaskwayak Creek Nation homes was also conducted. The households surveyed reported catching 25 lake sturgeon in 1999, 58 in 2000, and 33 in 2001. All reported catches of 1999 and 2001 were kept. A total of 199 fishers were interviewed at The Pas from June 1 to September 30, 2002. They reported catching 49 lake sturgeon, of which 26 were kept. The estimated total harvest at The Pas from June 1 to September 30, 2002 was 106 lake sturgeon. The length-frequency distribution of kept sturgeon was presented. A total of 147 fishers were interviewed at Cumberland House in 2002. They reported catching 21 lake sturgeon, of which 17 were kept. The majority of lake sturgeon were captured in June and July.

Northeast Science & Information. 2005. A framework to monitor the status of lake sturgeon (*Acipenser fulvescens*) in Ontario. Recommendations from the workshop: Developing a Framework to Monitor the Status of Lake Sturgeon, March 1-2, 2005, Sault Ste. Marie, Ontario. iii + 24 p.

The purpose of this workshop was to develop a framework for reporting on the status of lake sturgeon in Ontario. The distribution, status and management of lake sturgeon in Ontario was discussed. Participants recommended that the juvenile/sub-adult stage be monitored because they are easier to capture, their abundance is a good indicator of population status and the broad range of ages may aid in the identification of strong and weak year classes. Participants also recommended that Fall Walleye Index Netting be used to sample the juvenile and sub-adult lake sturgeon due to its cost and effectiveness, and that this be carried out on a mix of index and random sites within monitoring units. Next steps are discussed.

Nowak, A.M. 1984. Status of the lake sturgeon fishery lower Groundhog River, Kapuskasing District. Ontario Ministry of Natural Resources, Kapuskasing Dist. MS. Rep. 67 p.

This document was not available for annotating.

Nowak, A.M., and Hortiguera, M. 1986. Status of the lake sturgeon fishery in two reaches of the Mattagami River, Cochrane. Ontario Ministry of Natural Resources Technical Report. 59 p.

This document was not available for annotating.

Nowak, A.M., and Jessop, C.S. 1987. Biology and management of the lake sturgeon (*Acipenser fulvescens*) in the Groundhog and Mattagami Rivers, Ontario, p. 20-32. In C. H. Olver (ed.) Proceedings of a Workshop on the Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23.

The population was estimated at 8,492 fish with a corresponding annual production of 4,648 kg/hectare/year. The growth rate was fastest in the Groundhog River population. The youngest mature male was 19 years, and females 22 years; ages ranged from 9 to 49 years, and the sex ratio was 1:1. Mean muscle concentrations of mercury in fish from the Groundhog and Mattagami populations were 0.11 ppm and 0.17

ppm, respectively. Fish movements of up to 22 km upstream and 24 km downstream were recorded. Sport fishing catch equaled or exceeded production at the exploitation rate of 5%. Alternatives suggested to improve stock conditions included creating a fish sanctuary, placing constraints on sport fishing and imposing a slot limit on all sturgeon.

Nowak, A.M., and MacRitchie, I. 1984. A study of the Frederick House River, Cochrane District, 1981-1983. Ontario Ministry of Natural Resources, Cochrane Dist. MS. Rep. Pagination unknown.

This document was not available for annotating.

Olver, C.H. 1987. Introduction to the proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*), p. 1. In C. H. Olver (ed.) Proceedings of a Workshop on the Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23.

This short editorial note introduced the proceedings of the lake sturgeon workshop which was held on February 27 and 28, 1986. Most of the presentations focused on the biology and management of sturgeon in Ontario. Following the presentations, three working groups were formed to discuss management pertaining to sport and commercial fishing and enforcement.

Ono, R.D., Williams, J.D., and Wagner, A. 1983. p. 27-32 & 232-233. In Vanishing fishes of North America. Stone Wall Press Inc., Washington, D.C.

The general biology and habits of the lake sturgeon and the history of its exploitation were described without specific references to sources of information. The lake sturgeon was described as a threatened species.

Ontario Game and Fisheries Commission. 1912. The sturgeon, p. 76-80. In Final Report of the Ontario Game and Fisheries Commission 1909-1911. L.K. Cameron, Toronto, ON.

The history of lake sturgeon in Ontario was discussed and options for the management of a fishery were given. In most of the lakes that had been commercially fished, sturgeon were depleted. In less accessible waters, sturgeon were more abundant (north and west parts of

Ontario). The following recommendations were given: prosecute commercial fishing of sturgeon, if a sturgeon is caught by accident and cannot be returned to the water uninjured it should be shipped to the nearest government fish agency at the expense of the government, illegal traders should be fined \$100 for their first offense and \$200 and license cancellation for their second offense and trade in caviar should be banned unless certified by the government. It was also recommended that these provisions be relaxed for First Nations members, but that trading outside of reservations should be illegal.

Ontario Hydro. 1987. A strategy for hydroelectric generation planning and development. Ontario Hydro, Toronto, ON. Pagination unknown.

This document was not available for annotating.

Ontario Hydro. 1990. Hydroelectric generating station extensions Mattagami River environmental assessment. Ontario Hydro, Toronto, ON. Various pagination.

Movements of lake sturgeon were monitored and spawning and potential spawning areas identified. Mercury, lead, arsenic and PCB levels were examined. Mercury in lake sturgeon exceeded 0.05 mg/kg and could not be correlated with size. In the sport fishery of the area lake sturgeon was identified as the third most preferred species. There is also an important lake sturgeon subsistence fishery, with an estimated 10% of the population of Moose Factory fishing for sturgeon. Most sturgeon were harvested near the junction of the Abitibi and Moose rivers, with limited numbers taken from Adam Creek and Little Long head pond. Mitigation measures were discussed.

Ontario Hydro. 1992. Review of environmental assessment, hydroelectric generating station extensions, Mattagami River. Ontario Ministry of the Environment, Toronto, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of Natural Resources. 1985. A lake sturgeon yield study on the Kenogami River. Geraldton District. Prepared by Ecologistics Limited, Thorndale, ON. 47 p.

This document was not available for annotating.

Ontario Ministry of Natural Resources. 1986a. Incidental fish species caught in the Kenogami River, 1985. Geraldton District. Prepared by Ecologistics Limited, Thorndale, ON. 70 p.

This document was not available for annotating.

Ontario Ministry of Natural Resources. 1986b. A lake sturgeon yield study on the Kenogami River. Year 2. Geraldton District. Prepared by Ecologistics Limited, Thorndale, ON. 77 p.

This document was not available for annotating.

Ontario Ministry of Natural Resources. 1986c. A sturgeon bibliography. 2nd Edition, Geraldton District. Prepared by Ecologistics Limited, Thorndale, ON. 52 p.

This document was not available for annotating.

Ontario Ministry of Natural Resources, Geraldton District. 1987. A lake sturgeon yield study on the Kenogami River, Year 3 - Phase I Report. Prepared by Ecologistics Limited, Thorndale, ON. v + 58 p.

A three year study was carried out to determine a yield model for lake sturgeon in the Kenogami River. Three separate study areas, Kapeesawatan, Ogahalla and Mammamatawa were examined. The first two sites yielded very small numbers of sturgeon. The Mammamatawa sample yielded 509 fish, 477 of which could be aged. Fish were 2-58 years old (mean 14.6 years). Total annual mortality was estimated at 2.8%. The length-age relationship was expressed by the equation $TL(\text{total length, cm}) = 2.291(\text{age, years}) + 29.26$ (after age 2), the age-weight relationship was given by $WT = 23.16(\text{age})^{1.473}$ and the weight-length relationship was given by $WT(\text{weight, gm}) = 0.0015(TL)^{3.26}$. Of the 85 sturgeon checked for sex, the male:female ratio was 1:0.47. The overall sex ratio for the Kenogami River sturgeon was 2 males: 1 female. Of the food items analyzed from stomach contents, crayfish accounted for 60.37%, clams for 6.64%, dragonflies for 5.18% and caddisflies for 7.34% of the volume of the contents. However, dragonflies and crayfish occurred with the highest frequency (53.33% for both), followed by caddisflies (46.67%), stoneflies (35.56%), mayflies (33.33%), dipterans (22.22%), snails

(15.56%), and clams (13.33%). When sturgeon reached 80 cm, they actively selected crayfish as food. The shorthead redhorse (*Moxostoma macrolepidotum*) was identified as the only fish with a diet similar enough to lake sturgeon to be a potential competitor. Males were matured at 20-25 years and females at 25-31 years. The mouths of the Little Ash River, the Pagwachuan River and the Kabinakagami River were identified as spawning areas. Sturgeon moved downstream in the fall to inhabit deeper areas over winter, and moved upstream during summer. The population was estimated at 640 – 3,432, depending upon the sampling period, with a total biomass of 1,327-4,908 kg. Based on the biophysical characteristics of the river, a qualitative estimate showed highest yields to be in regions where the river width was >300 m, depth was variable (0.5-1.5 m) with deeper pools, substrate was predominantly gravel, sand or rubble, vegetation was uncommon or absent, flow rate was high with numerous riffles and rapids, and where catostomids and whitefish were rare.

Ontario Ministry of Natural Resources. 1988. Management plan for the lake sturgeon in the Kenogami River. Hearst District. Prepared by Ecologistics Limited, Thorndale, ON. 58 p.

This report of a three year field study on lake sturgeon encompassed the Geraldton district portion of the Kenogami River and an area downstream to Mammamattawa. Lake sturgeon ages ranged from 2-28 years; age at maturity was 25-31 years for females and 20-25 years for males. The female:male sex ratio was 1:2. Between June 1985 and June 1986, 526 fish were sampled. Annual mortality was estimated at 2.8%. There appeared to be a downstream movement of fish in the fall and an upstream movement in the spring. Recommendations included the maintenance of a viable brood stock, possibility of a protected slot size of 105 to 130 cm fork length, and a maximum annual harvest of 175 kg. The commercial fishery was not considered viable. Consideration of a sport fishery was recommended as the economic benefits to the community would be much greater.

Ontario Ministry of Natural Resources. 1989. Kapuskasing district fisheries management plan, 1989-2000. Kapuskasing, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of Natural Resources. 1992. Partial bibliography of *Acipenser* sp. 1986-1992 in refereed journals. Lake of the Woods Fisheries Assessment Unit, Kenora, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of Natural Resources. 2001. Guide to eating Ontario sport fish. 21st ed. Queen's Printer for Ontario, Toronto, ON. 207 p.

This guide outlined areas where sturgeon could be recreationally fished in Ontario. It listed fish size in centimeters as well as consumption recommendations. The information may not have been up to date at printing.

Ontario Ministry of Natural Resources. 2004. Proposal for managing the sport fishery of lake sturgeon in Ontario. Peterborough, ON. 9 p. [Unpublished].

This document was not available for annotating.

Ontario Ministry of Natural Resources (Species at Risk Section). 2004. Species at risk in Ontario list. Peterborough, ON. 8 p.

This document contained lists of extinct, extirpated, endangered regulated, endangered not regulated, threatened, special concern, not at risk, and data deficient species in Ontario. The lake sturgeon was listed as "not at risk".

Ontario Ministry of Natural Resources. 2006. Proposal for managing the recreational fishery for lake sturgeon in Ontario (Draft). Fisheries Section, Peterborough, ON. 9 p.[Unpublished].

Regulatory options for the management of lake sturgeon fisheries in Ontario were described. Current regulations were reviewed and four management options presented. These included the use of sanctuaries in cases where action must be taken to ensure the sustainability of local lake sturgeon populations; an interim closure of the lake sturgeon sport fishery in Ontario; an interim catch and release only fishery; and more conservative recreational fishing regulations. Each of these options was briefly discussed.

Ontario Ministry of Natural Resources. Date unknown. Bibliography of sturgeon reproduction studies. Lake of the Woods Fisheries Assessment Unit, Kenora, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of Natural Resources. Date unknown. Lake sturgeon in Lake Superior. Ontario Ministry of Natural Resources, Lake Superior Management Unit, Thunder Bay, ON. 4 p. Available from http://www.fws.gov/midwest/sturgeon/omnrls_page.html [accessed 5 April 2006].

This project collected baseline information on the population status and habitat use of lake sturgeon in historic spawning tributaries of Lake Superior. The tributaries studied were the Kaministiquia, Nipigon and Black Sturgeon rivers. Lake sturgeon were captured using gillnets and were sampled for fork length, total length, girth, weight (when possible) and sex (when possible). All lake sturgeon were tagged, but aging structures were collected from only four. A total of 58 lake sturgeon were captured in 1998; 54 from the Kaministiquia River, 2 from the Nipigon River and 2 from the Black Sturgeon River. Length distribution data were summarized. Movement patterns were not discernible. Population estimates were not made due to the small sample size.

Ontario Ministry of Natural Resources, Lake Superior Management Unit. Date unknown. Lake sturgeon radio telemetry study. Thunder Bay, ON. 4 p. Available from http://midwest.fws.gov/sturgeon/lsmu-telestudy_rpt.htm [accessed 5 April 2006].

Twenty lake sturgeon caught in gillnets on the Kaministiquia River between 6 September and 2 October 2000, were implanted with radio transmitters. At writing, all had been located and were moving throughout the Kaministiquia River. The surgical procedure used to implant the transmitters was described in detail.

Ontario Ministry of Natural Resources and Minnesota Department of Natural Resources. 1996. Report of the Border Waters Lake Sturgeon Management Committee. Peterborough, ON and St. Paul, MN. 13 p. [Unpublished].

Issues, recommendations, and background information on lake sturgeon status in Lake of the Woods, Rainy River, Rainy Lake, and the Namakan Reservoir were discussed. Recommendations included: 1) standardization of the closed season (May 1 to June 30) across fisheries areas and jurisdictions for commercial and angling fisheries; 2) additional sanctuaries were not required, but may be in the future; 3) prioritization of known sites for rehabilitation and spawning habitat creation before addressing projects in current work plans; 4) maintenance of stable water levels and flows downstream of existing dams from April 15 to June 30 (critical spawning and incubation period); 5) basing future decisions on sturgeon allocations and target harvest levels on a review of current harvest and potential yield information (presented in report - Table 1); 6) monitoring of the commercial and subsistence sturgeon harvests; 7) monitoring the sport fishery through the use of surveys or questionnaires; 8) completion of studies to determine the discreteness of border waters stocks; 9) establishing population assessment programs using standardized sampling protocols and gear; 10) completion of a modeling exercise to examine the effects of various size limits on lake sturgeon populations; 11) management of populations to allow for natural recovery and if stocking is required it should be from local populations within the same gene pool; and 12) the production of a fact sheet on border waters lake sturgeon for distribution to the public.

Ontario Ministry of Natural Resources, and Minnesota Department of Natural Resources. 2000. Managing the recovery of the border waters lake sturgeon. Ontario-Minnesota border waters. Peterborough, ON and St. Paul, MN. 10 p.

This document discussed the history of lake sturgeon in Ontario-Minnesota border waters, its life history, North American distribution, current status, human impacts, habitat requirements and exploitation. It concluded with a description of First Nations involvement in lake sturgeon recovery, the sport fishery, and tagging.

Ontario Ministry of the Environment. 1978. Sport fish contaminant data for lake sturgeon, Moose River. Unpublished data. Toronto, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of the Environment. 1979. Sport fish contaminant data for lake sturgeon, Moose River. Unpublished data. Toronto, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of the Environment. 1990. Sport fish contaminant data for lake sturgeon, Mattagami River. Unpublished data. Toronto, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of the Environment. 1991. Sport fish contaminant data for lake sturgeon, Mattagami River. Unpublished data. Toronto, ON. Pagination unknown.

This document was not available for annotating.

Ontario Ministry of the Environment. 1999. Lake sturgeon return to Lake Ontario. Fish Facts: Environment topics at a glance **March**: 2 p.

Anecdotal evidence supporting the return of lake sturgeon to Lake Ontario was given. From 1992 to 1995 there were a few lake sturgeon sightings near Prince Edward County and in the Bay of Quinte region on Lake Ontario. In 1995, a commercial fisher caught a lake sturgeon on the Ontario side of West Lake Beach. In the summer and fall of 1996, commercial fishers caught 50-60 lake sturgeon off the west side of Wolfe Island. They were caught at depths of 8-21 meters with yellow perch gillnets and had a length range of 41-51 cm. Increases in lake sturgeon catches around the Bay of Quinte were also reported by commercial fishers.

Ontario Parks. 2004. Black Sturgeon River Park management plan. Ontario Parks, Northwest Zone, Thunder Bay, ON. 43 p. + maps.

The four objectives of this management plan fell into the categories of: protection, recreation, heritage appreciation, and tourism. The protection objective was "To protect the provincially significant natural features of the park including the Nipigon Moraine remnant; the unconsolidated transverse ridges; as well as rare and sensitive flora and fauna" (pg. 12). This included the lake sturgeon population. A general

discussion of fisheries can be found on pages 26-27. Habitat rehabilitation, in the form of restoration of fish passage at dams and migration barriers, the repairing of streambed damage caused by log drives, and the stabilization of eroding shorelines, might occur. Sport fishing was permitted, but might be restricted at certain times and locations by the park superintendent. There were no commercial fishing operations in the park and none were to be permitted. Stocking of native species was permitted in access, development and natural environment zones. Status Indians continued to be permitted to harvest natural resources within their treaty area and in accordance with the terms of their treaty.

Owen, J.B., Elsen, D.S., and Russel, G.W. 1981. p. 68-69 & 137-138. *In* Distribution of fishes in North and South Dakota basins affected by the Garrison Diversion Unit. Fisheries Research Unit, University of North Dakota, Grand Forks, ND.

Lake sturgeon was listed as one of the fishes to be potentially affected by the Garrison Diversion Unit (Table 2, p. 69). The species was reported from the Red River by Surber in 1920 and by Keheler and Kooyman from the Assiniboine River in 1957, but not in North Dakota.

Owsjannikow, P.H. 1872. *Über ein neuen Parasiten in den Eiern des Sterlet. Melanges biologiques Tires du Bulletin de L'Academie Imperiale des Sciences de St. Petersburg Tom. 8 (1871-1872). Presented in 1871.*

Unusual, pale colored eggs were found amongst darker, normal ones in the ripe egg masses in sterlets. One of these abnormal eggs was placed in water and after a few hours a colony of small worm like creatures emerged, each forming a group of four. Each individual was a heart shaped pyramidal structure with six hollow tentacles, of which two were different in structure. These lived for a few days in pure water, but for over two weeks in water full of microorganisms. Sometimes the digestive cavity appeared full and at other times empty. One individual was seen capturing a *Cyclops*. Individuals were seldom seen living very long in the paired form, and rarer as individuals. This organism was considered an exclusive freshwater form.

Paetz, M.J., and Nelson, J.S. 1970. Sturgeon family - Acipenseridae, p. 50-53. In *The fishes of Alberta*. Government of Alberta. Queen's Printer, Edmonton, Alberta.

A short account of the natural history of lake sturgeon was provided. Most of the annual catch was taken from the South Saskatchewan River between the junction of the Bow and Oldman rivers and the eastern boundary of Alberta. Angling for sturgeon in Alberta was opened after a long closure following a population decline. The lake sturgeon was first recorded from Alberta by Whitehouse in 1919 from the Bow River at Bassano as *Acipenser transmontanus* (white sturgeon).

Page, L.M., and Burr, B.M. 1991. Sturgeons: Family Acipenseridae, p. 25-28. In *A field guide to freshwater fishes*. The Peterson Field Guide Series®. Houghton Mifflin Company, Boston and New York.

The document described various freshwater species, including sturgeon, in terms of their family and genus characteristics, how to identify them, their range, similar species, and other significant information.

Palace, V.P. 1996. Oxidative stress in lake sturgeon (*Acipenser fulvescens*) orally exposed to 2, 3, 7, 8-tetrachlorobenzofuran, p. 163-194. In *Oxidative stress in lake trout (Salvelinus namaycush) exposed to organochlorine contaminants that induce the phase I biotransformation enzyme system*. Ph.D Thesis, University of Manitoba, Winnipeg, MB.

Polychlorinated dibenzofurans (PCDFs) are produced as byproducts from municipal waste incineration and are found in the effluent from kraft pulp and paper mills which use chlorine bleaching processes. There are 135 possible PCDF congeners, of which 2, 3, 7, 8-tetrachlorodibenzofuran (TCDF) is one of the most common and toxic found in aquatic ecosystems. Mixed-function oxidase (MFO) enzymes and phase II enzymes are thought to play a role in mediating the toxicity of TCDF. Juvenile lake sturgeon were fed gelatin containing 0, 0.16 or 1.6 ng TCDF per kilogram fish weight. Liver, kidney and blood samples were collected 10 and 27 days after exposure. MFO and Phase II enzyme activities were measured in the liver. Non-enzymatic and enzymatic antioxidant parameters were also

measured in liver and kidney samples. The liver and kidney showed elevated TCDF concentrations after 10 and 27 days for all lake sturgeon. Concentrations were higher after 10 days. At 27 days, polar metabolites were present in bile. This, coupled with the lower TCDF concentrations after 27 days, may mean that TCDF is metabolised and cleared in a short period of time. Oxidative stress was also produced by exposure to TCDF and/or metabolic enzyme activity.

Palace, V.P., Brown, S.B., Baron, C.L., Fitzsimons, J.D., and Klavervamp, J.F. 1998. Relationship between induction of the phase I enzyme system and oxidative stress: relevance for lake trout from Lake Ontario and early mortality syndrome in their offspring, p. 146-153. In G. McDonald, J. D. Fitzsimons, and D. C. Honeyfield (ed.) *Early life stage mortality syndrome in fishes of the Great Lakes and Baltic Sea*. American Fisheries Society, Symposium 21, Bethesda, Maryland.

Lake sturgeon were orally administered gelatin containing 2, 3, 7, 8-tetrachlorodibenzofuran (TCDF). Three dose groups, 0, 0.16 and 1.6 ng/kg body weight, each contained 10 lake sturgeon. Five individuals from each group were sampled 10 and 27 days after the single dose was given. TCDF exposure resulted in induced hepatic Phase I enzyme activity, elevated concentrations of lipid hydroperoxides, and reduced tocopherol concentrations in the liver. Hepatic Phase I enzyme activity was positively correlated with liver lipid hydroperoxide concentrations. These results indicated elevated oxidative stress and a decrease in stores of antioxidant vitamins. A similar study was conducted on lake trout and was the focus of this article.

Palace, V.P., Dick, T.A., Brown, S.B., Baron, C.L., and Klavervamp, J.F. 1996. Oxidative stress in lake sturgeon (*Acipenser fulvescens*) orally exposed to 2, 3, 7, 8-tetrachlorodibenzofuran. *Aquat. Toxicol.* **35**: 79-92.

Juvenile lake sturgeon were given gelatin containing concentrations of 0, 0.16 or 1.6 ng [³H]-2, 3, 7, 8-tetrachlorodibenzofuran (TCDF) per kg of fish weight. Liver, kidney, and blood were sampled 10 and 27 days after exposure. Phase I mixed-function oxidase (MFO) and Phase II (Glucuronyltransferase) enzyme

activities were examined in the liver. Concentrations of non-enzymatic (tocopherol, retinoids) and enzymatic (superoxide dismutase, catalase, glutathione peroxidase) antioxidant parameters were quantified in the liver and kidney. Elevated concentrations of TCDF were found in the liver and kidney at both 10 and 27 days. Lower tissue concentrations of TCDF at 27 days and the presence of polar metabolites in bile suggested rapid metabolism and clearance of the contaminant. MFO enzyme activity, measured as ethoxyresorufin-O-deethylase (EROD), was provoked in the liver with activity at the two sample periods reflecting the TCDF concentrations. Greater concentrations of hepatic lipid peroxides in both dose groups indicated that oxidative stress was produced by contaminant exposure and/or induced metabolic enzyme activity.

Palace, V.P., Evans, R.E., Wautier, K., Baron, C.L., Werner, J., Klavervamp, J.F., Kidd, K.A., and Dick, T.A. 2001. Altered distribution of lipid-soluble antioxidant vitamins in juvenile sturgeon exposed to waterborne ethynylestradiol. *Environ. Toxicol. Chem.* **20**: 2370-2376.

Juvenile lake sturgeon (430 ± 20 g) were used to determine the ability of ethynylestradiol (EE2) to alter concentrations of the lipid-soluble vitamins A and E in plasma, liver, and kidney. Concentrations of 0, 15, 60 or 125 ng EE2/L were given for 25 days. Vitellogenin concentrations increased dose dependently in plasma. In addition, vitamin E (tocopherol), A1 (retinol), and A2 (dehydroretinol) were raised by 60 and 125 ng/L concentrations. Esterified storage forms of vitamin A were slightly lower and vitamin E levels remained relatively unchanged in the livers of fish from the 125 ng/L dose. Vitamins A and E were depleted in the kidney of fish given doses of 60 and 125 ng/L. Total lipid content was raised in gonads of fish given the 125 ng/L dosage. Implications of vitamin depletion by estrogenic contaminants in juvenile fish needed further study.

Paradis, S. 2003. Efficiency of the Vianney-Legendre fish ladders at the Saint-Ours Canal National Historical Site, Richelieu River, Québec. *In* American Fisheries Society 133rd Annual Meeting, Québec City, Canada, August 10-14, 2003. Pagination unknown. [Poster abstract].

Parks, N.B. 1978. The Pacific Northwest commercial fishery for sturgeon. *Marine Fisheries Review* **40**: 17-20.

The commercial fisheries for white sturgeon (*Acipenser transmontanus*) and green sturgeon (*A. medirostris*) in the Pacific Northwest from 1880 to 1975 were discussed. The flesh was sold fresh and frozen, spinal marrow was dried for use in soups, swim bladders were used in the production of isinglass, and eggs were used for caviar. Areas and seasons fished, gear used, and future status of the fisheries were also discussed.

Parsley, M.J., and Beckman, L.G. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River. *North Am. J. Fish. Manag.* **14**: 812-827.

Spawning and rearing habitat availability for young-of-the-year and juvenile white sturgeon (*Acipenser transmontanus*) was estimated in three impoundments and a section of river that form the lower 470 km of the Columbia River. Habitat suitability criteria curves were presented for spawning, young-of-the-year and juvenile white sturgeon. The impoundments studied included the Bonneville, Dalles, and John Day pools. Results were given in hectares and as a percentage of the total surface area. Lake sturgeon were not discussed.

Parsley, M.J., Beckman, L.G., and McCabe, G.T., Jr. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. *Trans. Am. Fish. Soc.* **122**: 217-222.

Water temperature, depth, velocity, and substrate types were recorded at sites where eggs, larvae, young-of-the-year, and juvenile white sturgeon, *Acipenser transmontanus*, were collected. Spawning occurred in water with the greatest velocity, 8 km downstream from the four main dams. The most common substrates at sites where spawning occurred were cobble, boulder, and bedrock. Young-of-the-year were found at depths ranging from 9-57 m; at mean water velocities of 0.6 m/s; and over substrates of hard clay, mud and silt, sand, gravel, and cobble. Juveniles were located at depths ranging from 2-58 m; at mean water velocities of 1.2 m/s or less; and over substrates of hard clay, mud and silt, sand, gravel, cobble, boulder, and bedrock.

Patalas, J.W. 1988. The effects of commercial fishing on lake sturgeon (*Acipenser fulvescens*) populations in the Sipiweesk Lake area of the Nelson River, Manitoba, 1987-1988. Manit. Nat. Res. MS. Rep. **88-14**. vii + 38 p.

This report summarized data collected annually to evaluate the effects of management regulations on lake sturgeon in the Sipiweesk Lake area of the Nelson River. Totals of 80 and 110 sturgeon were sampled from the commercial harvests in 1987 and 1988 respectively. Fishes ranged in age from 12-87 years. There was little difference in age, length or weight distributions of the annual samples. The condition factor for sexes combined was 0.84 in 1987 and 0.82 in 1988, and analysis of the length-weight relationship showed that sturgeon grew isometrically. Calculated mean fork lengths for each age interval indicated that after 20 years of age, growth was linear at the rate of 10 mm/year. A low proportion of fish under 25 years and a high mean catch age indicated that the population was relatively well balanced. The data obtained from this study were compared to other studies carried of this population (Sunde, 1953-1959; Sopuck, 1977-1978). An explanation was advanced for the possible misinterpretation of data by Sopuck (1987) for the sample of 1977-1978. Analysis of sturgeon sizes for fish between 19 and 45 years of age showed a higher growth rate compared to samples of 1953-1956, indicating that a drastic population decline during the 1950's reduced intra-specific competition and increased food availability. However, the mean length-weight relationships and the condition factors did not change much over the years compared. The mean annual harvest between 1970 and 1987 was 2,688 kg, less than the estimated sustained yield or the catch quota. Recommendations for management included closure of the commercial sturgeon fishery to protect remaining stocks, annual sampling of the commercial catch to monitor population parameters, and studying the Nelson River population to improve long-term management of the species and prevent its extirpation.

Patrick, P.H., Sakuta, A., Poulton, S., and McLeod, E.A. 1998. Behavioral conditioning in fish using acoustic and light technologies, p. 408. In World Aquaculture '98 Book of Abstracts, February 15-19, 1998, Las Vegas, NV, World Aquaculture Society, Baton Rouge, LA. [Abstract only].

Acoustic experiment results involving hatchery lake sturgeon, walleye, and red claw crayfish were presented. Preliminary data on the use of an energy efficient light source in aquaculture were also presented.

Payne, D.A. 1987. Biology and population dynamics of lake sturgeon (*Acipenser fulvescens*) from the Frederick House, Abitibi and Mattagami rivers, Ontario, p. 10-19. In C. H. Olver (ed.) Proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. **23**.

Sturgeon populations from three river systems were compared. Populations from the Frederick House and Abitibi rivers appeared robust, while those from the Mattagami River were young, with few remaining large adults. This was supported by mean length, age, and relative biomass data, which were greater in the first two river populations. The Mattagami River population had a faster growth rate. Commercial over-harvest and water level fluctuations may have resulted in these differences. Recommendations were made to stop commercial fishing on the Mattagami River, allocate the Frederick House population to sport fishing, and adjust quotas and conditions for commercial licenses on the Abitibi River.

Peake, S. 1998. Sodium bicarbonate and clove oil as potential anesthetics for nonsalmonid fishes. N. Am. J. Fish. Manag. **18**: 919-924.

This study found that solutions of 2.66 g sodium carbonate per litre and 60 mg clove oil per litre were ideal as anesthetics for use on lake sturgeon. Clove oil was recommended over sodium bicarbonate for surgical procedures, but recovery took significantly longer when time under clove anesthesia was over 5 minutes.

Peake, S. 1999. Substrate preferences of juvenile hatchery-reared lake sturgeon, *Acipenser fulvescens*. Environ. Biol. Fishes **56**: 367-374.

The substrate preferences of hatchery-reared juvenile lake sturgeon were studied to determine if hatchery rearing affected natural instinctive behavior. The fish were given a choice of sand, gravel, and rock or smooth plastic bottom with varying water temperatures, velocities, and times of day. Sand was the substrate preferred most frequently. Water temperature did not

affect substrate preference, although small sturgeon (13.5 cm mean fork length) were more active in water at 19°C than at 6°C and most active in early morning and late evening hours. When a current of 5 cm/sec was generated, the preference of small sturgeon for the sand substrate increased slightly. The preference of large sturgeon (24.3 cm mean fork length) was not affected by varying conditions. It appeared that hatchery-reared lake sturgeon and wild lake sturgeon showed the same substrate preferences, implying that hatchery rearing did not affect instinctive behaviour.

Peake, S., Beamish, F.W.H., McKinley, R.S., Katopodis, C., and Scruton, D.A. 1995. Swimming performance of lake sturgeon, *Acipenser fulvescens*. Can. Tech. Rep. Fish. Aquat. Sci. **2063**: iv + 26 p.

This study examined the swimming endurance and critical speed of lake sturgeon to aid in the design of fishways for non-jumping fish species, such as lake sturgeon. Critical speed increased with temperature (7-21°C) and total length (12-132 cm). Endurance at constant and prolonged swimming speeds increased with temperature but was independent of temperature at higher burst speeds. Endurance increased with total length at all speeds.

Peake, S., Beamish, F.W.H., McKinley, R.S., Scruton, D.A., and Katopodis, C. 1997. Relating swimming performance of lake sturgeon, *Acipenser fulvescens*, to fishway design. Can. J. Fish. Aquat. Sci. **54**: 1361-1366.

The objective of this study was to create a model that related swimming endurance of lake sturgeon to length and flow characteristics of fishways. Endurance at prolonged swimming speeds increased with water temperature, but was independent of temperature at higher burst speeds. In addition, endurance increased with total length at all swimming velocities. The swimming ability, space requirements, and behaviour of lake sturgeon should be taken into account when building fishways to ensure the successful ascension of migratory obstacles.

Peake, S., Beamish, F.W.H., and McKinley, S. 1995. Swimming performance of lake sturgeon *Acipenser fulvescens*, p. 16. In Canadian Conference for Fisheries Research (CCFR), January 6-7, 1995. Ottawa, Ontario. [Abstract only].

Pearce, W.A. 1986. Methuselah of freshwater fishes - the lake sturgeon. Conservationist **41**: 10-13.

The lake sturgeon has been called the stone, rock, Ohio, red, or rubbernose sturgeon. The 25 known species of sturgeon were discussed. Eight of these were found in North America. Two of them, the lake sturgeon and shovelnose, were strictly freshwater. The decline of sturgeon populations throughout much of their range was discussed. Differences between the resources allocated for sturgeon culture in North America and the Soviet Union were outlined and it appeared that the major reason for the success of culture in the Soviet Union versus North America was government support. The projections were that a decline in the concentrations of lethal chemicals (PCBs, Mirex, and mercury), protection from exploitation, and continued environmental rehabilitation could allow populations to recover. The time frame could be 100 years and exploitation rates would have to be about 5% per year to maintain stable populations.

Pearse, A.S. 1924. The parasites of lake fishes. Trans. Wis. Acad. Sci. Arts Lett. **21**: 161-194.

Crepidostomum lintoni was briefly described based on collections made from the intestine of *Acipenser fulvescens*.

Pearson, W.D., and Pearson, B.J. 1939. Fishes of the Ohio River. Ohio J. Sci. **89**: 181-187.

This report discussed the historical fish fauna of the Ohio River and the disappearance and reappearance of certain species over time. The lake sturgeon, which was reported as a native of the Ohio River in 1818 by Rafinesque and in 1870 by Dumeril, was not reported after 1969 and had apparently been eliminated from these waters. It was the only species known earlier that has not been reported from the Ohio River for the previous 20 years. Lake sturgeon populations may have been extirpated by the installation of dams which interfered with the spawning migration. It was hoped that the recovery of several fish populations would serve as an incentive to try and revive lake sturgeon once more in the Ohio River.

Perron, D. 1983. Lake sturgeon, p. 147-158. *In* G. Watson, J. Grant and A. Wheatley. (ed.) Beyond the rainbow: alternative species for commercial aquaculture in Ontario. Aquaculture Development Program, Owen Sound, Ontario.

This document provided a description of lake sturgeon, its distribution, biology (including spawning), and fecundity. The author relied heavily on what was known on white sturgeon and gave interesting information on water quality parameters. Natural nutrition in the form of a condensed list of food items and formulated diets was discussed. The author concluded that "...for the time being, feeding a semi-dry, high protein diet produces adequate results." Culture methods included the use of raceways and ponds by the Russians and the use of circular tanks in California. Incubation has been successful (average 90%) with McDonald (Bell) jars, Williams troughs, and upwelling boxes. Work in Wisconsin used nylon net cages in the summer with transfer indoors during the ice period. Predictions were that a 4.5-6.0 kg lake sturgeon could be produced in 3-6 years. The environmental impact of sturgeon introductions was unclear but the suggestion was made, based on the literature, that they could consume large numbers of eggs of other species or introduce parasites such as *Polypodium*. A table outlining the total production of sturgeon by Canada from 1975 to 1980 (133 metric tonnes for 1980) and other world producers was taken from an FAO report of 1981. Lake sturgeon markets were discussed and values as high as \$22.00/kg were quoted for smoked meat versus unsmoked sturgeon at \$3.90 to \$4.40/kg. Values given for white sturgeon larvae were \$0.40/1,000 or \$0.15/100,000, fry \$0.75/1,000 or \$0.30/100,000, and for fingerlings \$2.50/100 or \$1.50/1,000-5,000 (it was not clear from the report if values were in Canadian or US dollars). The final recommendations were not very optimistic on the establishment of lake sturgeon culture in Ontario, due to markets, international competition—especially from Europe, and lack of warm water.

Peterson, D.L. 2003. Reintroduction of lake sturgeon in the Coosa River, Georgia, p. 52. *In* 2003 Southern Division American Fisheries Society Annual Spring Meeting, Wilmington, North Carolina, 12-16 February, 2003. [Abstract only]. Available from http://www.sdafs.org/meetings/03sdafs/Abstracts_2003_final.pdf [accessed 6 April 2006].

Peterson, D.L., and Gunderman, B. 2000. Current status of lake sturgeon in the Manistee River of northern Lake Michigan. *In* 130th AFS Annual Meeting, St. Louis, MO, 20-24 August, 2000. Reflections. Pagination unknown. [Abstract only]. Available from http://www.ecu.edu/org/afs/St_Louis/abssturgeon/r951432905-80.htm [accessed 6 April 2006].

Peterson, D.L., and Vecsei, P. 2004. Lake sturgeon of the Muskegon River: population dynamics and life history. Final report for the Great Lakes Fishery Trust. Project Number 2001.113. University of Georgia, Warnell School of Forest Resources, Athens, GA. 32 p.

This document was not available for annotating.

Peterson, D.L., Gunderman, B., and Vecsei, P. 2002. Lake sturgeon of the Manistee River: a current assessment of spawning stock size, age, and growth, p. 175-182. *In* W. Van Winkle, P. J. Anders, D. H. Secor, and D. A. Dixon. (ed.) Biology, management, and protection of North American sturgeon. American Fisheries Society, Symposium 28, Bethesda, Maryland.

Population estimates were obtained using the Schnabel population estimator and fish were aged from cross-sections of the pectoral fin ray. Back-calculations of length-at-age revealed that growth rates of Manistee River lake sturgeon were slightly higher than those of previous studies of lake sturgeon in similar areas. Spawning run estimates were 106 in 1999 and 57 in 2000. However, one half of the sample was composed of juveniles, suggesting that the actual number of spawning adults was less than 50 individuals in each year.

Petrushevski, K.G., and Shulman, S.S. 1958. The parasitic disease of fishes in the natural waters of the USSR, p. 299-319. *In* V. A. Dogiel, G. K. Petrushevski, and Y. I. Polyanski (ed.) Parasitology of fishes. [Translated from Russian by E. Kabata, 1961. Oliver and Boyd, Edinburgh-London].

This item was not available for annotating.

Phillips, G.L., Schmid, W.D., and Underhill, J.C. 1982. How big do they get?, and Family Acipenseridae, the sturgeons, p. 29-31 & 61-63. *In* Fishes of the Minnesota Region. University of Minnesota Press, Minneapolis, Minnesota.

This book contained a brief account of the lake sturgeon and its life history characteristics. The Minnesota record for this species stood at 162.8 lbs, caught at Rainy River Koochiching County on May 15, 1968.

Phoenix, R.D. 1991. Movements of Lake Sturgeon in the Upper Groundhog River (1988-89). Ontario Ministry of Natural Resources, Kapuskasing District. 41 p. [Unpublished].

Lake sturgeon movements were monitored by radiotelemetry in the Groundhog River from May 1988 to March 1989. Seven adult lake sturgeon were surgically implanted with radiotransmitters. Variable movement patterns were revealed. The known distances travelled ranged from 23 to 43 km. In spring (mid-May to early June), all sturgeon used the area immediately below Carmichael Falls. There was a general dispersal of lake sturgeon in summer and early fall. By late fall (November 25, 1989), four of the seven sturgeon returned to the area below Carmichael Falls. Further research into sturgeon habitats was recommended so the results of this study could be interpreted.

Phoenix, R.D., and Rich, C.J. 1988. Utilization of a proposed small hydroelectric site on the Groundhog River by lake sturgeon, *Acipenser fulvescens*. Ontario Ministry of Natural Resources, Kapuskasing, ON. 15 p. + app.

This study was conducted in response to plans for a hydroelectric structure at the site. The area below Carmichael Falls on the Groundhog River was a significant lake sturgeon nursery area, based upon high numbers of juveniles using the site. Little spawning activity was observed during the study. Lake sturgeon did not spawn in 1988 or spawned at other locations. The authors recommended that the spawning population be relocated and that the hydroelectric development accommodate natural flow regimes and substrate conditions in order to maintain the habitat.

Pikitch, E.K., Doukakis, P., Lauck, L., Chakrabarty, P., and Erickson, D.L. 2005. Status, trends and management of sturgeon and paddlefish fisheries. *Fish Fish.* 6: 233-265.

A review of world wide sturgeon and paddlefish fisheries was provided. The lake sturgeon catch peaked in 1885 in Lake Erie at 2,500 tonnes. The most recent Canadian catch was given as

223 tonnes in 1997. Lake sturgeon were also noted as being commercially important in the international caviar trade. The CITES export quota for Canadian lake sturgeon was 170 tonnes of meat in both 2001 and 2002. In 2003, the quota was reduced to 101.5 and included both meat and food and canned products. In 2004, the quota was zero. A brief discussion of lake sturgeon commercial, sport and subsistence fisheries in Canada and the U.S. was included on pages 250-251. The authors rated the status of species discussed in the review with regard to management effectiveness, restoration capacity and habitat. Out of a possible best score of 12, lake sturgeon were rated a 5 for all of North America. Conservation priorities were recommended.

Planimark. 1993. p. 4-33, 45, & 51-54. In Evaluation of existing and potential markets for the Waswanipi fish processing plant products. Presented to the Cree Regional Authority, Nemaska, QC. Funded by the Department of Fisheries and Oceans under the Québec Federal Fisheries Development Program.

Waswanipi processing plant products include smoked lake sturgeon filets, whole sturgeon, fresh or frozen whitefish filets with or without skin, whole butterflied smoked whitefish, whitefish eggs, minced fish, walleye cheeks and caviar. Products in competition with lake sturgeon from Waswanipi in the Québec market included lake sturgeon from the St. Lawrence sold hot smoked and sliced in 85 g packages with a wholesale price of \$2.71/lb, Atlantic sturgeon from the St. Lawrence River with a wholesale price of \$6.24/lb including delivery, and lake sturgeon from the St. Lawrence River from Pêches St-Angèle de Trois-Rivières sold hot smoked and unsliced for a wholesale price of \$6.10/lb. U.S. and other smoked fish products in competition with Waswanipi lake sturgeon were also discussed. A 100 grams of lake sturgeon meat contains 105 calories, 16.1 grams of protein, 4 grams of fat and 0.9 grams of saturated fat; it does not contain any cholesterol or sodium. Market tests were conducted and the results presented. At writing, the plant charged \$8/lb for lake sturgeon smoked filets and \$40-\$50/lb of lake sturgeon caviar.

Plohman, J. 2000. The function of the lake sturgeon (*Acipenser fulvescens*) thyroid system and dietary effects. M. Sc. Thesis, University of Manitoba, Winnipeg, MB. xiii + 166 p. Available from www.collectionscanada.ca/thesescanada/index-e.html [accessed 6 April 2006].

This study examined low plasma T3 and T4 levels in laboratory raised and wild lake sturgeon to: 1) determine if the blood properties could explain the low levels of thyroid hormone (TH), 2) analyze several types of lake sturgeon tissue for TH levels, 3) assay the tissues for the presence of TH deiodination activities, and 4) determine the response of the lake sturgeon thyroid system to dietary change. The sturgeon were found to have low T3 and T4 values, with the T3 values being consistently higher than the T4. Low binding of TH by plasma proteins was the likely cause of the low levels of TH in the blood plasma. Almost all sturgeon tissues had higher levels of T3 than T4, with the thyroid and brain having the highest concentrations of T3. The high T3 concentrations in the thyroid suggested that T3, rather than T4, was the primary TH released from the thyroid gland. Results of the tissue assays supported this suggestion. The results of the diet experiment suggested a role of T3 in the growth of lake sturgeon. Lake sturgeon thyroid function was also compared to that of teleosts and mammals.

Plohman, J.C., Dick, T.A., and Eales, J.G. 2002a. Thyroid of lake sturgeon, *Acipenser fulvescens*. I. Hormone levels in blood and tissues. *Gen. Comp. Endocrinol.* **125**: 47-55.

Thyroid hormone levels were measured in plasma, whole carcass, and tissues of 2-year-old lake sturgeon kept in freshwater; and in serum of adults during spawning time from the Winnipeg River. Circulating thyroxine (T4) and 3, 5, 3'-triiodothyronine (T3) levels were low in all cultured fish and most adults, with a few adults having significantly higher levels of T4 and T3. The proportions of blood TH found in erythrocytes were 19.5% (T4), 6.1 % (T3), and 6.9% (reverse T3=rT3). Equilibrium dialysis exhibited significantly higher percentages of plasma free (F) FT4 (1.1%), FT3 (0.4%), and FrT3 (3, 3', 5'-triiodothyronine=rT3, 3.0%) for sturgeon when compared to rainbow trout. This suggested a more limited TH binding to sturgeon plasma sites. T3 levels were greater than T4 levels in most extrathyroidal tissues of cultured

sturgeon but were generally less than 0.1 ng/g and 10 to 100 fold lower than reported for salmonids, with the exception of whole brain T3 concentrations (5.6 ng/g). The digested thyroid contained 21.3 ng T3/g and 2.4 ng T4/g. Lake sturgeon appeared to have a low circulating reserve of bound TH but had FT4 and FT3 concentrations close to those of salmonids. The thyroid may be a significant direct source of T3, the primary TH in sturgeon tissue. High serum T4 and T3 levels in some sturgeon during spawning suggested a thyroid role in reproduction.

Plohman, J.C., Dick, T.A., and Eales, J.G. 2002b. Thyroid of lake sturgeon, *Acipenser fulvescens*. II. Deiodination properties, distribution, and effects of the diet, growth, and a T3 challenge. *Gen. Comp. Endocrinol.* **125**: 56-66.

Properties and tissue distribution of thyroid hormone (TH) deiodination activities were measured *in vitro* at subnanomolar substrate levels for cultured 2-year-old lake sturgeon kept at 12 to 15°C. Deiodination responses to an exogenous 3, 5, 3'-triiodothyronine (T3) challenge and to a diet-induced growth suppression were also examined. Thyroxine (T4) outer-ring deiodination (T4ORD), T4 inner-ring deiodination (T4IRD), T3IRD, and 3, 3', 5'-triiodothyronine (rT3) ORD activities were seen in the liver and intestine and resembled properties of teleosts. T3IRD and T4IRD activities were dominant in the brain. There was low or slight deiodination in any form in the gill, skeletal muscle, kidney, notochord, or immature gonad. Hepatic T4ORD activity was variable during photophase but was highest during the late morning. A dietary T3 challenge that doubled plasma T3 levels decreased hepatic T4ORD activity without altering any other deiodination pathways in the liver, intestine, or brain. Somatic growth and plasma T3 levels, increased hepatic and intestinal T3IRD activities, and hepatic rT3ORD activity were observed when the diet was changed from trout pellets to ocean zooplankton, but did not modify hepatic or intestinal T4ORD activity. Plasma T3 in lake sturgeon could be derived from thyroid and hepatic (and intestinal) T4ORD activity, which varied with sampling time and downregulated in response to a T3 challenge. A decrease in T4ORD activity was attributed to an increase in hepatic and intestinal T3IRD activities. Overall, these results implied that there was a difference

in emphasis in thyroidal regulation between sturgeon and some teleosts.

Poly, W.J., and Cavender, T.M. 1992. Indexed and partially annotated bibliography of *Acipenser fulvescens*; with additional references concerning culture of other sturgeon species. Museum of Zoology Contributions for 1992 No. 1. Ohio State University, Columbus, OH. Pagination unknown.

This document was not available for annotating.

Porter, B.A., Cavender, T., Fuerst, P., and Nickell, T. 1995. Genetic status of lake sturgeon in Lake Erie and other populations from the Laurentian Great Lakes. The Ohio State University Museum of Biological Diversity. Contribution #1 for 1995, Museum of Zoology, Fish Division. 45 p.

The genetics of sturgeon from Lake Erie were investigated using protein electrophoresis and compared to populations from Lake St. Clair, the St. Lawrence River, Menominee River, Lake Winnebago, Lake Huron, and the Wolf River. Only the lactate dehydrogenase enzyme system (LDH) contained enough variability to be used to understand population structure. Three LDH phenotypes were found in Lake Erie sturgeon. Caution was given because the Lake Erie phenotype seemed to be genetically distinct and the introduction of stocks could accelerate the loss of lake sturgeon from Lake Erie by promoting the integration of genetically different strains into a remnant population.

Porter, B.A., Fuerst, P.A., Krieger, J., Booton, G.C., Mark, B.D., Kibbey, M., and Cavender, T.M. 1997. Genetic studies of lake sturgeon (*Acipenser fulvescens*): Report on the population acquisition and disposition of tissue samples at the Ohio State University. The Ohio State University Museum of Biological Diversity. Contribution #3 for 1997, Museum of Zoology, Fish Division. 34 p.

This document discussed the plight of lake sturgeon in the Great Lakes region. Work of the Sturgeon Genetics group at the Ohio State University was highlighted. In addition, they asked for more samples of lake sturgeon tissue from any location. Instructions for preservation of the sampled tissue were included.

Porter, B.A., Schug, M.D., Cavender, T.M., and Fuerst, P.A. 1997. DNA fingerprinting (multilocus VNTRs) used to study population differences in lake sturgeon in the Great Lakes, p. 562. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Power, M., and McKinley, R.S. 1997. Latitudinal variation in lake sturgeon size as related to the thermal opportunity for growth. Trans. Am. Fish. Soc. 126: 549-558.

The relationships between age-specific total lengths, weights, condition factors, and a measure of the thermal opportunity for growth (TOG, the sum of degree-days above 5°C) were determined for lake sturgeon from 16 populations spread throughout the species natural range. Individuals with the smallest TOG were shorter, weighed less, and had a lower condition factor at any given age. There was a higher correlation among weight and condition factor as the sturgeon aged. However, TOG was still a poor indicator of the differences in condition at a given age among the populations. Growth rates at higher latitudes showed a significant inverse relationship once the TOG had been adjusted. The latitudinal countergradient in growth rates partially balanced for lower growth opportunities at higher latitudes.

Preston, G. [1994?]. Use of drift nets to capture lake sturgeon fry. Ontario Ministry of Natural Resources, Lake Nipissing Fisheries Assessment Unit. 5 p.

Gillnets were set in the Sturgeon River below the dam at Sturgeon Falls in 1991 and 1992. Thirty-five adult lake sturgeon were caught during the last week of May and first week of June in both years. Weight ranged from 6.3 to 45.3 kg. Downstream movement of fry peaked on June 19th in 1992 and June 23rd in 1993. The highest catches occurred between 9pm and 1am. In 1992, 473 fry were caught over 318.1 hours of drift net fishing; in 1993, 2,519 fry were caught over 67.5 hours of drift net fishing. The cause of this increased catch was not entirely clear. It may have been due to higher water levels in 1993 or to habitat improvements made in the fall of 1992. The sturgeon fry mortality rate was 9.3% in 1992 and 4.8% in 1993. Mortalities

were caused by contact with large fish in the nets or suffocation from pulp effluents or other debris. Detailed diagrams of the drift net assembly were provided.

Price, E.W. 1942. North American monogeneic trematodes. V. The family Hexabothriidae n.n. (Polystomatoidea). *Proc. Helminthol. Soc. Wash.* **9**: 39-56.

A new family of monogenean trematodes, Hexabothriidae with Dicylbothriidae as a new subfamily, was erected. *Dicylbothrium armatum* was described with the following morphometrics: body = 2.5-13 mm x 225 μ m-1.1 mm; anterior oval bothria = 80-150 μ m; posterior haptor = 320 μ m-1 mm x 320-800 μ m; 6 muscular suckers with hook 400-470 μ m; posterior appendix 225-320 x 120-240 μ m; haptor suckers striated, sucker or haptor appendix 60 μ m, with 3 pairs of hooks, oral aperture 136-400 μ m from anterior end of body; pharynx 64-100 x 64-96 μ m; 2 pairs of eyes present; muscular cirrus = 160-320 x 50-160 μ m; median genital aperture 240-680 μ m from anterior end; eggs = 208-224 x 88-140 μ m.

Priegel, G.R. 1964. The sturgeon spearer. *Wis. Conserv. Bull.* **29**: 18-19.

This popular article on sturgeon from Lake Winnebago described the spear fishery from the second week of February through March 1. Spearers often scattered mussel shells, shelled corn, and egg shells over the bottom to increase visibility. Decoys included ears of corn, wooden toy airplanes and carved replicates of fish. There were 3,352 licenses sold in 1961, 3,242 in 1962, and 4,522 in 1963. Spearfishing success increased the sale of licenses in the following year and an average 15% of sturgeon spearers were successful. Information was provided on who bought a sturgeon spearing license, the time of day when sturgeon were caught, the average age of the successful spearer, and the type and cost of equipment (total value usually in the order of \$150).

Priegel, G.R. 1973. Lake sturgeon management on the Menominee River. *Wisc. Dept. Nat. Res. Tech. Bull.* **67**: 19 p.

A 26 mile long section between Grand Rapids Dam and White Rapids Dam was studied in 1969 and 1970 to estimate the lake sturgeon population and determine the exploitation rate. A.C. boom shockers were used to sample fish

and the population estimates for fish ≥ 42 inches (legal fish size) were 234 in 1999 and 185 in 1970. The age of the fish sampled ranged from 1-45 years. The fishing pressure was calculated to be 14,300 hours in 1969 and 11,400 hours in 1970. Opening weekends accounted for 20-30% of the annual fishing pressure. The estimated exploitation rate was 13% in 1969 and 17% in 1970. This was based on angler harvest data and exceeded the desirable exploitation rate of 5%. The majority (78%) of the fishermen were from Wisconsin. The minimum legal sized fish (42 inches) belonged to the 12 year age group and all fish of 17 years of age were 42 inches or more. Growth of the Menominee River sturgeon was slower than those in Lake Winnebago, which weighed more than Menominee sturgeon at a given age. Management recommendations included increasing the size limit to 50 inches, introducing special licenses or registration for lake sturgeon fishing, reduction of the bag limit to one fish from the current two, and closure of the season during October.

Priegel, G.R., and Wirth, T.L. 1971. The lake sturgeon - its life history, ecology, and management. *Wis. Dept. Nat. Res. Publ.* **240-70**: 19 p.

Life history characteristics of the lake sturgeon were reviewed with special reference to Wisconsin water-bodies. Food and feeding habits were described. Various food items such as insect larvae, leeches, snails, small clams and miscellaneous invertebrates were sensed with barbels, strained and washed through their gills, and sucked in by a protrusible mouth. Lake Winnebago sturgeon had a strong homing tendency after traveling upstream for as much as 125 river miles to spawn. Spawning occurred during late April and early May in central Wisconsin. Sturgeon spawned in areas where there was upwelling or "slowly boiling" water, with rocks, boulders and broken concrete slabs forming steep angles into the water such as shallow, rocky river banks. When water flow was high and water temperatures rose slowly, spawning began at water temperatures of 53°F. In seasons of low water flow and rapid temperature rise, spawning began only when water temperatures reached 58-59°F. Males were observed at spawning sites ahead of females, and cruised the site in groups of eight or more. Spawning commenced when females joined the group and one or more males vibrated simultaneously beside a female during one act

of oviposition which lasted for 5 seconds, after which the group moved to deeper waters until the next act of oviposition. A female spent 5-8 hours in spawning activity and 50,000-700,000 eggs could be released by a female. Egg and milt release was accompanied by vigorous tail thrashing. Females reached maturity in 24-26 years and spawned every 4-6 years while males reached maturity in 11-14 years and spawned every year or in alternate years. Eggs hatched in 5 days at 60°F or above and small sturgeon displayed schooling behavior in late summer and early fall. No serious attempt at artificial propagation had been made in the U.S. Growth in length was more rapid than weight until sexual maturity, after which weight increase was proportionately more rapid. Factors contributing to the mortality of sturgeon and a decline in populations included human over-exploitation, alteration of spawning habitat, predation on eggs by fish, and predation on young by aquatic mammals (otters). The history of the fishery was reviewed and spearing remained the dominant method of harvesting.

Priegel, G.R., and Wirth, T.L. 1975. Lake sturgeon harvest, growth, and recruitment in Lake Winnebago, Wisconsin. Wis. Dept. Nat. Res. Tech. Bull. **83**: 25 p.

A registration system from 1955 to 1969 was used to determine the characteristics of the spearer, harvest, age-weight-length relationships, population size, and recruitment of lake sturgeon from Lake Winnebago. Average spearing success from 1962-1967 was 15.9%, with residents of the four counties surrounding Lake Winnebago accounting for 78.2-83.8% of the fish speared. The total harvest for the period 1955-1969, was 8,981 fish, ranging from 8-1,505 per year (312 - 64,715 lbs.) with an average annual harvest of 599 fish. The number of fish harvested depended upon good weather conditions and water clarity. The average annual length of lake sturgeon harvested was 54.5", and the registered lake sturgeon ranged in age from 7-68 years. Captured fish represented year classes from 1907-1960 (in all but 3 fish). None of the year classes showed trends of decline over this period of time and no individual age group was consistently speared with greater frequency. The length-weight relationship, calculated from 40-70 inch fish, resulted in the equation $\text{Log}W = -4.0371 + 3.2530 \text{ Log}L$, where W is weight in pounds and L is total length in inches. The population of lake sturgeon over 40

inches long was estimated at a maximum of 11,500. To maintain 1969 population levels, the annual harvest should not exceed 4.7%.

Priegel, G.R., and Wirth, T.L. 1978. Lake sturgeon populations, growth, and exploitation in Lakes Poygan, Winneconne and Lake Butte des Morts, Wisconsin. Wis. Dept. Nat. Res. Tech. Bull. **107**: 23 p.

Studies were carried out over the period 1952-1976 to assess harvest, growth, and population structure of lake sturgeon in the above lakes to determine if over-exploitation had occurred. The total harvest over this period was 124,904 lbs (4.5 lb/acre), with an average of 10,408 lb/year (1 lb/2.6 acres). From 1954-1976, Lake Poygan accounted for 77.1% of the fishing pressure. Harvested fish represented year classes from 1916-1955. Individual year classes peaked when they entered the fishery at age 15-16. There was a general decline of larger fish (50-55", 55-59" and >60" groups), especially after 1957, and the proportion of fish under 50" increased from 61.6-63.8% in 1952-54 to 84.5% in 1971. The length-weight relationship was expressed by $\text{Log}W = -3.900 + 3.135 \text{ Log}L$, based on 2,278 fish 40-70" in total length, where W is weight in pounds and L is total length in inches. Registered lake sturgeon were from 8-43 years old and 45.2% of the total harvest. Average length and weight increased with increasing age of fish (42" and 12 lbs at 10 years to 66" and 69 lbs at 39 years). The population was estimated at 3,700-5,200 fish of 40 inches and longer. Different growth rates shown by the Lake Winnebago and Poygan-Winneconne basin populations were interpreted to indicate distinct populations with little mixing between them, although they used the same spawning grounds. The possibility of homing behaviour in young sturgeon was suggested and further research into the biology was urged. Management recommendations included maintaining the fishing season, limiting fishing pressure, and regulating harvests through a minimum size limit.

Prince, E.E. 1899. The food of the sturgeon. Can. Sess. Pap., Spec. Rep. Append. 31st Ann. Rep. Dept. Mar. Fish. **1898**: lvi-lx.

In view of frequent allegations of the sturgeon being voracious consumers of the spawn and fry of commercially important fish, the author reported on investigations into the food items of

sturgeon as found in their gut. Specific mention was made of examinations of white sturgeon and specimens from St. John River. The lake sturgeon was not specifically mentioned and it was implied that the North American sturgeon had similar food habits.

Prince, E.E. 1905. The Canadian sturgeon and caviare [*sic*] industries. Can. Sess. Pap. 22. Spec. Append. Rep.: liii-lxx.

This was an excellent report of the status of sturgeon in Canada. The value of the sturgeon fishery to Canada and information on the potential extent of the sturgeon in Canada was discussed. The author commented on the fact that sturgeon was the main source of food of Indians for a considerable portion of the year, but at this time (late 1800s) there was practically no demand for it as a white man's food. Within the 10 years preceding the date of this report the fishery began to have considerable value in the Great Lakes, but even more important was the rapid development in the Lake the Woods (claimed to be the most valuable in the world). By 1895 the sturgeon fishery was important in Lake Winnipeg and other Manitoba waters. The sturgeon taken from Lake Winnipeg were considered the best in the world due to their "...rich edible qualities..." Applicants wanting to fish sturgeon throughout Canada rated them the top fish, along with salmon. It was the value of sturgeon products that increased fishing pressure. These products included: (1) caviar; (2) isinglass; (3) the flesh salted, smoked; (4) oil for the leather industry; (5) fertilizer, made from entrails and scrap; (6) the soft grisly backbone with its sheath which prepared was called wesinga and in Russia was an esteemed article of diet; (7) the brain and nerve cord removed from the gristle when smoked and dried was considered a great delicacy in China; (8) the back portion of the sturgeon or dorsal region was made into a food product called balyki; (9) the ventral part or belly of the fish was made into a food called pupki; (10) a valuable fish glue, differing from isinglass of the swim-bladder, was made from the nose, fins, tail; and (11) the skin produced leather for mill belts and boot laces. Interestingly, Canadian fishermen did not appreciate the value of the roe as contracts would state that the meat was worth 10 cents a pound but the waste (the roe, swim-bladder) was to be carefully kept and handed over for nothing. St. Clair fishermen received 4-5 cents/pound for the meat, 10 cents/pound for

caviar, and 5 cents/pound for swim-bladders. Lake Erie sturgeon were found to yield up to 12 gallons of eggs per fish. Sturgeon were usually fished while migrating and an example was given from the Volga river in Russia where large numbers were killed. Methods of capture varied but included large 12 inch mesh nets, baited hooks, bare grapnels, fish traps or pound nets. The Lake of the Woods was used as an example for the decline of the sturgeon fishery. Canadian regulation enforcement over the greater part of the lake and on the Rainy River would have permanently preserved the fishery, but a very small part of the lake fell within the United States border where most of the sturgeon were taken, so much so that the value of the fishery declined from 1,059,267 pounds in 1894 to 197,033 pounds in 1899. So important was the fishery at this time that the New York Fishing Gazette (June 1886), quoted by the Winnipeg Colonist, wrote that the Lake of the Woods fishery produced 75% of the worlds caviar and practically controlled the world caviar industry. In 1886, 190,000 pounds of caviar were produced from Lake of Woods. At the peak of the Lake of the Woods sturgeon fishery there were 14 steamboats, fifteen barges, a large number of so-called pound-boats, and employment for 500 men. The money brought to Rat Portage from sturgeon sales was \$200,000, annually. Even with this destructive fishing, there were people with enough insight to report on the importance of lake sturgeon as a food source to Indian populations in the western regions of Canada. A well-informed Dominion officer urged the formation of reserves for sturgeon on Lake Winnipeg and other waters of the west "...as these waters have the last available supply in the known world untouched." The economics to the Indians were clear as it was a source of meat and oil, and the caviar could be exported. A female sturgeon with roe was worth more than a beaver. A description was given for the handling of sturgeon roe and the preparation of caviar. There were two types of caviar, the fresh or grain caviar (zernistaia ikra) and hard or pressed caviar (paiousnaia ikra). Sturgeon flesh was greatly prized by some, while others would not eat it. Isinglass was considered the finest quality of glue and was almost pure gelatin. The swim-bladder was removed, cleaned and dried in sheets. The best isinglass was a flexible white semi-transparent flaky material, devoid of taste and smell. Even in Roman times, isinglass was highly valued and by 1905 it retailed for \$3.00 a pound. It was used as a food for the sick due to

its nutritious, pure, and unirritating qualities, for cooking and confectionery, and for refining wines and beer. There was a brief discussion of food items consumed by sturgeon with a reference to fish in the diet.

Probst, R.T. 1954. Why study sturgeon? *Wis. Conserv. Bull.* **19**: 3-5.

Attention was drawn to the lack of knowledge about sturgeon populations in Wisconsin, preventing the formulation of wise management strategies. Recommendations included tagging studies with a large sample size and obtaining pectoral fin rays and gonads from spear fishermen. The technique of using sections of the pectoral fin ray for aging was discussed. The size regulations governing sturgeon fishing were seriously questioned in view of the advanced age of maturity and spawning of lake sturgeon. The possible need for modifying existing regulations was discussed.

Probst, R., and Cooper, E.L. 1955. Age, growth and production of lake sturgeon (*Acipenser fulvescens*) in the Lake Winnebago region, Wisconsin. *Trans. Am. Fish. Soc.* **84**: 207-227.

The age and growth of lake sturgeon in the Lake Winnebago area (including lakes Butte des Morts, Poygan and Winneconne) were assessed from 966 fish caught between 1951-1954. Fish ranged between 30-79 inches in length. Lake Winnebago yielded a greater proportion of bigger fish (>60 inches) than the other lakes. The method of age determination used the marginal pectoral fin ray and the validity of the method was discussed. Age ranged between 1-82 years. The length-weight relationship of lake sturgeon from Lake Winnebago was $\log W = -4.01939 + 3.24070 \log L$ in comparison to $\log W = -4.12298 + 3.26625 \log L$ for Lakes Poygan, Winneconne and Butte des Morts, where W is weight in pounds and L is total length in inches. The length-weight relationship for the combined data was given by $\log W = -4.17096 + 3.30367 \log L$. Length-weight relationships were "practically identical" for males and females. The male: female sex ratios for Lakes Poygan, Butte des Morts, and Winneconne were nearly 1:1, whereas in Lake Winnebago, females were 72.4% of the sample. Tendipedid larvae (86.6% occurrence) were the most important food item taken by sturgeon in Lake Winnebago, with sturgeon from the other smaller lakes feeding

frequently on ephemeropteran larvae.

Puzach, C. 2003. 2003 Lake Winnebago sturgeon health survey. La Crosse FRO Accomplishment Highlights Report. United States Fish and Wildlife Service. **March**: 1. Available from <http://www.fws.gov/midwest/LaCrosseFisheries/publications/index.html> [accessed 6 April 2006].

Twenty-six lake sturgeon harvested in the 2002 Lake Winnebago spear fishery were sampled. Kidney and spleen samples, length, weight and spawning condition were taken for each lake sturgeon. Kidney swabs were taken to screen for *Aeromonas salmonicida*, *Yersinia ruckeri*, *Citrobacter freundii* and *Edwardsiella ictaluri*. Kidney samples were also screened for *Renibacterium salmoninarum*. Kidney and spleen samples were screened for Infectious Pancreatic Necrosis, *Oncorhynchus masou* viruses and Infectious Hematopoietic Necrosis Virus. Samples were negative for all of the bacterial pathogens. Virus screening results were not available at the time of writing.

Pyatskowitz, J.M. 2001. Lake sturgeon reintroduction plan on the Menominee Indian Reservation. In American Fisheries Society 131st Annual Meeting. 2001: A Fisheries Odyssey - The Journey of Science and Education Continues. Phoenix, AZ, 19-23 August, 2001. Pagination unknown. [Abstract only].

Pyatskowitz, J., Kincaid, H.L., Krueger, C.C., and May, B. 1997. Inheritance of microsatellite loci in sturgeon (*Acipenser fulvescens*). p. 455. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Pyatskowitz, J.D., Krueger, C.C., Kincaid, H.L., and May, B. 1996. Inheritance of microsatellite loci in lake sturgeon, p. 83-88. In S. Doroshov, F. Binkowski, T. Thuemler, and D. MacKinlay (ed.) Culture and management of sturgeon and paddlefish symposium. International Congress on the Biology of Fishes. San Francisco State University, San Francisco, CA, July 14-18, 1996.

Lake sturgeon were sampled from the Menominee River, Wisconsin. A section of fin was removed from each fish with half being stored in alcohol and the other half in a lysis

buffer for later DNA extraction. Adults that were captured in spawning condition were held in 1.8 m diameter tanks to spawn on their own. Milt was collected from three males and eggs were stripped from one female. Three families were created by fertilizing three sets of eggs with milt from different males. All resulting fry were sampled at hatch. Seven families were also created from two females and four males captured in the St. Lawrence River, Québec. DNA extraction techniques were briefly outlined. Five of twelve loci examined were polymorphic. These included LS-19, 34, 39, 54, and 68. LS-19, 34, and 54 had two alleles, LS-39 three alleles, and LS-68 four alleles. LS-58, 62, and 73 were monomorphic, and LS-22, 23, 57, and 69 were inconclusive. At the time of writing, polymorphic loci were being examined to determine the mode of inheritance. Preliminary results indicated that polymorphic loci exhibit tetrasomic inheritance.

Pyatskowitz, J.D., Krueger, C.C., Kincaid, H.L., and May, B. 2001. Inheritance of microsatellite loci in the polyploid lake sturgeon (*Acipenser fulvescens*). *Genome* **44**: 185-191.

Inheritance in the expression of amplicons for four microsatellite primer pairs was completed using 10 families created from gametes of lake sturgeon captured from the Menominee River, Wisconsin, below the White Rapids Dam. Mode of inheritance for loci that showed four gene doses and meiotic drive were determined using Chi-squared tests. Loci *Afu34* and *Afu68* showed a maximum of two even-intensity bands per individual and had descendant genotype ratios that fit domestic inheritance ($P > 0.05$). Genotype expression at both loci showed that one female parent had given unreduced gametes. Primer *Afu39* amplified products that exhibited four gene doses, where genotype counts fit expected ratios for disomic inheritance ($P > 0.05$) indicating amplification of products from two disomic loci that shared alleles. Meiotic drive, the unequal distribution of alleles into gametes, was shown at the *Afu39* loci based on a test for random segregation ($P > 0.05$). The only loci to express tetrasomic inheritance was *Afu19* from a single progeny, which had the potential to be produced from a double reduction gamete. No evidence for octoploid inheritance was noted.

Quinlan, H.R. 2000. Studies of larval and juvenile lake sturgeon in the Bad River, 1997-1998. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 11 p. Available from <http://www.fws.gov/midwest/ashland/sturgeon/badriver/sturg98.html> [accessed 6 April 2006].

This study examined the general spawning locations of lake sturgeon in the Bad River, the timing and extent of larval downstream movements, the length of river residency and habitat use by juveniles, and associated fish species. Most larval lake sturgeon started to drift downstream 7-14 days after hatching. Between 1997 and 1998, 41 larval lake sturgeon were captured. Larval fish from other families included Catostomidae, Percidae, Cyprinidae, and Centrarchidae. The substrate in the area where most (29) larval lake sturgeon were captured was cobble, rock, and sand. At the remaining locations, the substrate was sand. Five juvenile lake sturgeon were captured in 1998. They were captured in a depth range of 0.6-1.4 meters over a substrate of mainly sand with some pea gravel. Water temperature ranged from 22 to 23°C. Larval growth rate from May to early June was 1.1 mm/day total length, and from early June to early August, 3.3 mm/day total length. Biological data was summarized.

Quinlan, H., Elliott, R., Zollweg, E., Bryson, D., Boase, J., Weisser, J., Auer, N.A., Baker, E., Carlson, D., Eggold, B., Holtgren, M., and Mohr, L. 2005. Proceedings of the second Great Lakes lake sturgeon coordination meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. Funded by the Great Lakes Fishery Trust. 78p. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/2004STNCoordMtg.pdf> [accessed 6 April 2006].

This meeting addressed three issues identified as priorities at the 2002 meeting. Namely, sturgeon passage issues and approaches, habitat classification, and habitat restoration and enhancement. Oral presentations (24) fell into the following categories: Sturgeon Genetic Structure and Stocking Considerations; Genetic Conservation, Stocking and Hatchery Rearing; Status Assessment Technique; Habitat Classification, Restoration and Enhancement; Sturgeon Passage; and Regulations, Status Determination and Rehabilitation Progress. Nine posters were also presented. Abstracts for all of

the presentations are included and some contain links to the full presentation (online version). A series of discussion summaries and a meeting evaluation followed the abstracts.

Quintal, R.T., Crawford, E.S., Hill, T.D., Chernyak, S.M., Begnoche, L.J., and Hickey, J.P. 2003. Non-lethal sampling technique for the determination of organic contaminants in lake sturgeon (*Acipenser fulvescens*), p. 123. In International Association for Great Lakes Research 46th Annual Conference & International Lake Environment Committee 10th World Lakes Conference. Global threats to large lakes: managing in an environment of instability and unpredictability. June 22-26, 2003. DePaul University, Chicago, Illinois. [Abstract only].

R.L. & L. Environmental Services Ltd. 1991. A study of lake sturgeon (*Acipenser fulvescens*) movements, abundance, and harvest in the South Saskatchewan River, Alberta. Prepared for Alberta Recreation, Parks and Wildlife Foundation and Alberta Fish and Wildlife Division. vi + 55 p. + apps.

This study was initiated in 1985 to supplement available data on sturgeon and to provide information for the management of sturgeon populations in the South Saskatchewan River. Data were collected on angling effort, catch composition, harvest, life history, and fish movement. Approximately 45.8% of the 153 anglers were specifically fishing for sturgeon. The catch rate was 0.27 lake sturgeon/angler trip and 0.035 lake sturgeon/hour. A total of 203 lake sturgeon were captured during the study, with most being taken from one location near the boundary of the Canadian Forces Base Suffield, 185 km downstream of Grand Forks. A total of 188 sturgeon were tagged and 31 were equipped with radio transmitters. Twenty-six tags were returned by anglers from 1985 to 1990. While some fish remained near their release point, many moved up to 185 km upstream and downstream. Many mature fish showed upstream movement in the spring followed by downstream movement, characteristic of spawning behavior. There was little fish movement in colder water temperatures. The Grand Forks area was identified as a potential major spawning area. The researchers suggested further investigation in order to identify critical habitats, to better understand the maturation and development of lake sturgeon, and to assess the status of

populations in the South Saskatchewan River.

R.L. & L. Environmental Services Ltd. 1992 (Final Revisions 1994). Management of lake sturgeon (*Acipenser fulvescens*) sport fisheries in Alberta. Prepared for World Wildlife Fund/Prairie for Tomorrow and Alberta Fish and Wildlife Division, Edmonton, AB. i + 38 p.

Maturity, spawning habitat, early life history, age and growth, movements, and habitat and feeding were examined for lake sturgeon in Canada, and the population and habitat status of lake sturgeon in Alberta was summarized. Limiting factors included age at maturity, spawning periodicity, habitat disruptions from dams and barriers, and water quality. Sport harvest levels were tabulated for Alberta from 1968 to 1989 and for the South Saskatchewan River from 1982 to 1989. Alberta/Saskatchewan transboundary issues included the lack of size or angling restrictions, other than a maximum allowable catch of one fish per day, and the presence of a commercial lake sturgeon fishery in Saskatchewan. Regulations in Alberta included a creel limit of two sturgeon per angler, a minimum size limit of 100 cm total length, mandatory possession of a sturgeon angling license and a general angling license, and mandatory tagging of each sturgeon kept with a metal tag included with the sturgeon license. Habitat management and protection recommendations included designating the Grand Forks location as a sanctuary, identifying and mapping spawning and nursery sites used by lake sturgeon in Alberta, identifying other possible critical habitats and concentrations of sturgeon and monitoring them for signs of stress, identifying flow and physical/chemical habitat requirements for critical locations on the North and South Saskatchewan rivers, and identifying the impact of water management/flow relationships on sturgeon habitat. Harvest management recommendations included season closure from March 15 to July 1, re-evaluating the minimum size limit, and discussing the development of common regulations in Saskatchewan and Alberta. Angler catch monitoring recommendations included continuing the annual sturgeon questionnaire, and considering mandatory registration of harvested lake sturgeon. Education and information recommendations included the distribution of a pamphlet on lake sturgeon with each angling license purchase, holding public meetings prior to implementing the management

plan, and encouraging catch and release angling. Recommended areas of study for biological research included population estimates, life history data, habitat restoration and enhancement, contaminant levels, and lake sturgeon culture. Each recommendation was briefly discussed.

R.L. & L. Environmental Services Ltd. 1997. Fisheries inventories of the lower Bow, lower Oldman, and South Saskatchewan rivers 1995-1996. Prepared for Alberta Environmental Protection, Natural Resources Service, Fisheries Management Division, Lethbridge, Alberta. viii + 90 p. + app.

This study documented the distribution, movements, and life history characteristics of lake sturgeon, primarily because of their importance to the recreational fishery on the South Saskatchewan River. A total of 73 lake sturgeon were sampled with an additional 21 observed during electrofishing. Lake sturgeon were caught at all indexed sites in the South Saskatchewan River and at some sites on the Oldman and Lower Bow rivers. The catch was dominated by young age-classes (70%), while adults 20 years or older comprised only 7% of the catch. The shift towards a younger population age structure was attributed to overharvesting of older fish. The study concluded that lake sturgeon were harvested near maximum allowable limits from 1980 to 1990.

R.L. & L. Environmental Services Ltd. 1998. Fish movements in the South Saskatchewan River basin 1996-1997. Prepared for Alberta Conservation Association, Lethbridge, Alberta. vii + 33 p. + 2 apps.

This study monitored migratory movements of radio tagged fish in the South Saskatchewan River basin, determined spawning aggregations, and monitored water temperatures in the Bow, Oldman and South Saskatchewan rivers. Between 1995 and 1997, 60 lake sturgeon were tagged. Tagging locations included the Bow River (1), the Oldman River (1), and the South Saskatchewan River (58). Only one of the tagged fish had been recaptured. It was tagged at kilometer 68 of the South Saskatchewan River on August 6, 1996 and recaptured and released by an angler on July 12, 1997 at the same location. Fourteen lake sturgeon were radio tagged. Fork length ranged from 530 to

1,405 mm, and most fish were 18 years old or younger. Most lake sturgeon travelled less than 2 km from their release sites in the winter, indicating an overwintering area. Variable movement patterns were displayed in spring and summer. Additional mark/recapture and radio tagging studies were recommended to determine seasonal habitat use.

Rach, J.J., Gaikowski, M.P., Howe, G.E., and Schreier, T.M. 1998. Evaluation of the toxicity and efficacy of hydrogen peroxide treatments on eggs of warm- and coolwater fishes. *Aquaculture* **165**: 11-25.

Eggs of northern pike, walleye, yellow perch, white sucker, lake sturgeon, paddlefish, common carp, and channel catfish were cultured and hydrogen peroxide treatments were initiated on non-eyed eggs until all viable eggs had hatched. Eggs were treated from Monday to Friday for 15 minutes with 0, 500, 1,000, 3,000 or 6,000 $\mu\text{L}\cdot\text{L}^{-1}$ of hydrogen peroxide. The mean percent hatch was greatest when eggs were treated with the 100 $\mu\text{L}\cdot\text{L}^{-1}$ hydrogen peroxide. Common carp, lake sturgeon, and paddlefish were the least sensitive to hydrogen peroxide treatments, with percent hatching ranging from 40% to 48% in the 6,000 $\mu\text{L}\cdot\text{L}^{-1}$ hydrogen peroxide treatment. Almost all treated eggs remained clear of fungus infection, while the control groups were reduced or eliminated by fungal infections.

Rach, J.J., Howe, G.E., and Schreier, T.M. 1997. Safety of formalin treatments on warm- and coolwater fish eggs. *Aquaculture* **149**: 183-191.

To test the safety of formalin treatments, non-eyed eggs of walleye, common carp, white sucker, channel catfish, and lake sturgeon were treated for 45 minutes every second day with 1,500, 4,500, or 7,500 $\mu\text{L}\cdot\text{L}^{-1}$ formalin treatments up to hatching. For all species the percent hatch was greater in 1,500 $\mu\text{L}\cdot\text{L}^{-1}$ treatment groups than the untreated groups. Walleye eggs were the least sensitive and had a hatch of 87% in the 7,500 $\mu\text{L}\cdot\text{L}^{-1}$ treatment. Lake sturgeon were the most sensitive species with a mean hatch of 54% in 1,500 $\mu\text{L}\cdot\text{L}^{-1}$ treatments. Most of the treated groups were free of infection while the untreated groups suffered significantly from fungal infections.

Radford, D.S. 1972. The harvest of lake sturgeon (*Acipenser fulvescens*) in the South Saskatchewan River from 1968 to 1972. Alberta Lands and Forests, Fish. Manage. Rep. **13**: iv + 19 p.

Questionnaires were sent to anglers who purchased a sturgeon angling license between 1968 and 1972. A total of 279 licenses were sold and on average 74% of the questionnaires were returned annually. On average 83% of respondents actually fished for sturgeon, and 32% caught at least one. Of the 168 lake sturgeon reported caught, 91 were released. The extrapolated harvest totalled 111 for all years of study. The average weight was 14 pounds with an average range of 2.5-68 pounds. On average of 79% of respondents favoured the use of minnows as bait, and 97% favoured the continuation of the season. Mark-recapture data were presented for 5 lake sturgeon. All data were presented by year. Recommendations included allowing dead minnows to be used as bait, a minimum size limit of 36 inches total length, the retention of sturgeon angling licenses to provide a record of anglers, maintaining the daily catch and annual limit of two sturgeon, the retention of the tag system to limit the harvest of trophy sturgeon, and that angling be limited to the South Saskatchewan River, the only area in Alberta for which significant data on the lake sturgeon population was available. Angler residence was also summarized.

Radford, D.S. 1976. The 1974 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Dept. Rec. Pks. Wildl. Fish. Manage. Rep. **21**: v + 27 p.

Based on returned questionnaires from licensed anglers, 42 sturgeon were reported caught, of which 25 were released. The estimated harvest was 21 sturgeon. The average weight of the catch was 17.3 pounds. There was one recapture of a sturgeon tagged in 1969. The largest sturgeon caught weighed 60 pounds, and 65% of the reported catch was taken at or near the Grand Forks area. The sturgeon population of the South Saskatchewan River was discussed and the harvest was compared to previous years. Recommendations included considering regulations to check the harvest of juveniles and adults, improving enforcement of legislation against illegal fishing, and annual monitoring of the sturgeon harvest.

Radford, D.S. 1977a. The 1975 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Dept. Rec. Pks. Wildl. Fish. Manage. Rep. **25**: iv + 16 p.

Questionnaires were sent to anglers who purchased a sturgeon angling license in 1975. A total of 107 licenses were sold, and 85% of questionnaires were returned. Ninety-two percent of respondents actually fished for sturgeon, and 48% caught at least one. Of 150 lake sturgeon reported caught, 33% were kept. The estimated annual harvest was 64 fish. The average weight was 18 pounds with a range of 2-90 pounds. The mean weight of sturgeon released was 12 pounds, and the mean weight of sturgeon kept was 32 pounds. Results were compared to those from previous years and angler residence was summarized. Recommendations included maintaining the current regulations, the annual assessment of lake sturgeon harvest in the South Saskatchewan River, the development of a new management policy if harvest becomes unfavourable, and maintaining a sustained yield of lake sturgeon above 15 pounds.

Radford, D.S. 1977b. The 1976 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Dept. Rec. Pks. Wildl. MS. Rep. 17 p.

One hundred and thirty one questionnaires were mailed to purchasers of sturgeon angling licenses (1976/77); 72% were returned and 87% of the respondents fished for sturgeon. Eighty two sturgeon were caught and 48 of these were released. The size distribution of the catch was similar to previous years. The average weight of sturgeon released was 12 pounds while the average weight of sturgeon kept was 33 pounds. A sturgeon tagged in 1969 was reported in the catch from Estuary, Saskatchewan. A map of the sport fishing area was included.

Radford, D.S. 1978. The 1977 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Dept. Rec. MS. Rep. 16 p.

One hundred and twenty seven questionnaires were mailed to purchasers of sturgeon angling licenses (1977/78); 82% were returned and 89% of the respondents fished for sturgeon. Seventy sturgeon were caught and 46 of these were released. The size distribution of the catch was

similar to previous years. The average weight of fish kept was 32 pounds (14.5 kg) and the average weight of those released was 11 pounds (5 kg). There was an overall decline in the catch compared to previous years. Blooms of *Cladophora* in the South Saskatchewan River were extensive due to drought conditions. Tables included historical records from 1968 on the number of licenses issued, summaries of the catch from respondents to a questionnaire, size distribution of sturgeon caught, and approximate average weight of sturgeon.

Radford, D.S. 1979. The 1978 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. v + 18 p.

One hundred and forty nine questionnaires were mailed to purchasers of sturgeon angling licenses (1978/79); 84% were returned and 76% of the respondents fished for sturgeon. Eighty sturgeon were caught and 50 of these were released. The size distribution was similar to previous years but the trend to a higher proportion of large fish in the catch stopped in 1978. The average weight of fish kept was 26 pounds (11.8 kg) and of those released was 10 pounds (4.5 kg). In the 1978 harvest, possible over-exploitation of the fishery was evident in the general decline in angler success and the poor representation of sturgeon weighing over 35 pounds. Tables presented cumulative data since 1968.

Radford, D.S. 1980a. The 1979 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. v + 21 p.

A record number of sturgeon angling licenses were sold in 1979. A total of 24% of the respondents caught at least one sturgeon. Respondents caught 144 sturgeon in total but released 105 of them. In 1979, the estimated harvest was 46 sturgeon. The size distribution was similar to the long-term norm from 1968 to 1978. The largest sturgeon taken in 1979 weighed 161 pounds, an unofficial Alberta record. The average weight of sturgeon caught was 15 pounds, with the average weight of sturgeon kept and released being 32 and 9 pounds, respectively. Approximately 31% of the catch came from the Grand Forks area, 17% from the Rattlesnake area, 18% from the Bull Pen area, 31% from Sandy Point, and 3% from

unknown areas. There was no evidence of sturgeon overexploitation in the South Saskatchewan River, so no changes to regulations were recommended.

Radford, D.S. 1980b. The harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta between 1968 and 1978. Alberta Energ. Nat. Res. Fish Wildl. Div. MS. Rep. vi + 35 p.

The sturgeon season was closed in 1940 and then reopened in 1968. From that time an annual questionnaire evaluated the harvest and a special \$5 license was required to fish for sturgeon. Only 2 fish could be in possession and each must have been tagged. There was also a minimum size limit of 36 inches (from tip of tail to tip of snout) and a weight of approximately 10 pounds. A total of 886 licenses were sold between 1968 and 1978, an average of 82% of questionnaires were returned, 84% of respondents fished for sturgeon, and 36% caught at least one sturgeon. Of 625 sturgeon caught, 44% were kept. Approximately 10% of those kept were larger than 35 pounds. The official angling record for Alberta was a 72 pound sturgeon caught in 1978; the unofficial record was a 90 pound sturgeon caught in 1975. The Alberta lake sturgeon population size was estimated at 2,890. Based on tagging results, there appeared to be two movements above and below Medicine Hat. A map illustrated the location and general movements, which appeared to be related to spawning. Recommendations were that legislation should remain in effect, the ratio of fish over 10 pounds and the proportion of the catch over 35 pounds (10%) should remain the same, and nutrient loading should be reduced.

Radford, D.S., and Wiebe, P.J. 1973. The 1973 harvest of lake sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River. Alberta Lands and Forests, Fish. Manage. Rep. 14: iv + 15 p.

A total of thirty questionnaires were sent to anglers who had purchased a 1973/74 sturgeon license. A total of 83% of the respondents fished for sturgeon, and 47% reported catching at least one. Of 33 sturgeon caught, 17 were kept. On average, the sturgeon weighed 13.8 pounds. All respondents favored continuation of the sturgeon angling season. The majority of the license holders resided in southern Alberta.

Rafinesque, C.S. 1817. Addition to observations on the sturgeons of North America. Amer. Mo. Mag. 1: 288.

This reference appeared in a report on the sitting of the Literary and Philosophical society of New York on July 10, 1817 and reported that the author's paper in question was read before the society. In this "memoir" Rafinesque indicated that the lake sturgeon was a distinct species and proposed the name "*Acipenser fulvescens*" due to its "dark fulvous colour". The brief description stated that it reached 6 feet in length, possessed a short obtuse snout, falcated dorsal fin, smooth skin, with the lateral of the five rows of shields composed of more than 40 small shields. This was the first description of lake sturgeon and the first binomial nomenclature attributed to it. The type locality was the Great Lakes. [In the following year, Le Sueur (1818, see in this bibliography) described the lake sturgeon and gave it the name *A. rubicundus*. This seemed to have been the more widely circulated name, as *A. fulvescens* did not appear in Kirsch and Fordice's 1889 review of North American acipenserids.

Rafinesque, C.S. 1820. Fourth part - Atelosian fishes, p. 78-87. In Ichthyologica Ohiensis or natural history of the fishes inhabiting the Ohio River and its tributary streams, preceded by a physical description of the Ohio and its branches. W.G. Hunt, Lexington, Kentucky.

Under the title "Atelosian fishes", the author provided an account of several species of sturgeon-"*Acipenser*". In his introduction preceding the individual species accounts, Rafinesque stated the names of seven North American species in which he includes *A. rubicundus* (LeSueur's 1818 designation for the lake sturgeon) but did not mention his own 1817 designation of *A. fulvescens*. This was followed by descriptions of six new species of which *Acipenser maculosus*, *A. serotinus*, *A. ohiensis*, and *Dinectus truncatus* were considered synonyms of the lake sturgeon by Kirsch and Fordice (1889) (see in this bibliography).

Raikova, E.V. 1958a. A historical investigation of the parasitic larva of *Polypodium hydriforme* Ussov (Coelenterata). Dokl. Acad. Nauk SSSR 121: 549-552. (In Russian) (English version in Doklady Akademii Nauk SSSR, Biological Sciences Section 121: 604-608).

Early stages of *Polypodium hydriforme* were found in sturgeon in stage III of maturity. The material was fixed in a variety of fixatives, embedded in paraffin and sectioned at 5, 7, and 1 μ m thickness. The outer and inner layers of the parasite body were made of epithelial cells 9 x 5 μ m, separated by a layer of interstitial cells. Cells of the outer layer were ciliated. DNA content was the same in cells of these three layers, while cytoplasmic RNA was particularly abundant in the interstitial cells. Distal granules of the inner cell layer of the embryo contained acid mucopolysaccharides while the parasitic stolon had such granules in the outer layer, indicating that this layer was the ectoderm. The capsule of the parasite origin, was formed of a homogenous substance containing large, often complex shaped nuclei, and may have been involved in the hypothesized extracellular yolk digestion.

Raikova, E.V. 1958b. The life cycle of *Polypodium hydriforme* Ussov (Coelenterata). Zool. Zh. 37: 345-358.

Eggs of 78% of *Acipenser ruthenus* females, of stages III, IV, and V of maturity, were infected with *Polypodium* in the lower stream of the Kama River. The parasite life cycle was correlated with the developmental cycle of the host's ovaries. Infection of the eggs took place in June-July, at stage III of ovarian maturity. The parasite had inversely arranged embryonic layers, and in the eggs of stage IV, the larva became a stolon with buds. In the spring, prior to spawning, the stolons evaginated, exposing their ectoderm to the outside and this phenomenon may have been brought about artificially by pituitary injection. During spawning, stolons emerged from released infected eggs and divided into single polyps which reproduced by means of longitudinal division. Polyps cultured for 130 days had male and female gonad development after 6-7 weeks. Unisexual individuals were found more often than hermaphroditic ones. The infection with *Polypodium* was not transmitted to succeeding generations of oocytes; after spawning and following development to stage III, the sturgeon eggs were free from *Polypodium*, as the period of oocyte maturation from stage III to maturity took less than a year to complete. (From the summary following the Russian original).

Raikova, E.V. 1959a. On the infection of the Volga sterlet with *Polypodium hydriforme* Ussov (Coelenterata). Izv. Gos. Nauchno-issled. Inst. Ozer. Rechn. Rybn. Khoz. **47**: 207-208.

One hundred and thirty-three Volga sturgeon (*Acipenser gueldenstaedti*) were examined; 53 were summer samples (shortly before spawning migration) and 80 were winter samples (in the stage III of ovarian development). Only 10 individuals were infected, all of them from the winter sample. The parasitic stage of *Polypodium* was found in stage III of egg maturity. During the anadromous migration the sterlet ova had already reached stage IV of maturity and the parasitic stolons possessed buds. In August, near Saratov, stolons with reversed germ layers and buds, but without tentacles, were recovered from sterlet ova in stage IV of development. The tentacles were formed in September and the stolon overwintered in this state within stage IV sterlet eggs. In May of the next year, just before spawning, the germ layers attained their normal positions. The *Polypodium* left the sterlet along with healthy eggs, when the eggs were laid. The developmental cycle of *Polypodium* closely followed the maturation cycle of the sterlet ova. The infection of eggs with *Polypodium* depended upon the stage of maturity of the eggs with which the sterlet entered the streams; *Polypodium* could infect only the immature ova of the winter sterlet. *Polypodium* probably lived only in freshwater and not marine environments. (From the German summary following the Russian original).

Raikova, E.V. 1959b. *Polypodium hydriforme*. In Parasites of freshwater fish and the biological basis for their control. Bulletin No. 49 of State Sci. Research Institute of Lake and River Fisheries. Translation No. **TT61-31056**. United States Department of Commerce. Pagination unknown.

This item was not available for annotating.

Raikova, E.V. 1960. Morphological and cytochemical investigation of parasitic stage of the life cycle of *Polypodium hydriforme* Ussov (Coelenterata). Tsitologiya **2**: 235-251.

Histological sections (5-10 μm thick) were prepared from "roe-corn" of 35 sturgeon females infected with *Polypodium hydriforme*. The differentiation of the larval tissues was

described. The larval capsule was formed by the migration of the endodermal cells and the confluence of the cytoplasm and nuclei of these cells. The nuclei became polyploid and phagocytosis of yolk granules by the capsule was observed. With an increase in the size of the stolon, the capsule became thinner and eventually disappeared during evagination of the stolon. Larval endodermal cells were initially identical and each had a rhizoplast and one flagellum. The beginning of endodermal differentiation occurred with the formation of the tentacle anlagen. As the capsule fragmented, the endodermal cells in contact with the yolk became tall and narrow, with elongated nuclei at their bases. These cells began phagocytosis of the yolk. The distal ends of the cells accumulated late neutral mucopolysaccharides or mucoprotein. Structures comparable with ergastoplasm rings appeared in some endodermal cells. Muscle cells differentiated before tentacle formation and were rich in glycogen but poor in RNA. The mesoglea of the tentacles contained proteins, polysaccharides and glycogen and the ectodermal cells contained prominent vacuoles, with basally situated nuclei. The cytoplasm contained glycogen and spheroid granules of acid mucopolysaccharides and proteins at the distal ends. Thread cells developed in clumps at the site of the tentacle anlagen, with large or small capsules without protein or glycogen, but contained cnidocils. Cnidoblasts with large capsules predominated in the anlagen of the supporting tentacles, while those with small capsules were found in the feeler tentacles. Cnidoblasts contained RNA and glycogen. The cnidial anlage elongated, forming anlage of a proteinaceous thread cell filament, and acid mucopolysaccharides appeared in it during maturation. Glycogen content decreased in all but the stolon tentacle cells during evagination.

Raikova, E.V. 1961a. Cytological peculiarities of free-living stages of development of *Polypodium hydriforme* Ussov (Coelenterata). Tsitologiya **3**: 400-412.

Polyps were collected from infected roe of sterlets and cultured in a microaquarium. Histological sections (5-7 μm thick) of the polyps were prepared at regular intervals during the free-living period, and variously stained. Cells of the endoderm and ectoderm were described. Ectodermal cells were made up of epithelial, nettle, and interstitial cells and were the same as

those of the parasitic stolon. The acid monosaccharide layer at the distal ends of the ectodermal cells was in contact with the environment and dissolved to form a prospective mucous membrane around the polyp. Interstitial cells were more basophilic than the epithelial ectodermal cells. Cells of the muscle layer were formed from the interstitial cells of the ectoderm. The cnidia represented a hollow tube that was everted when ejected. Endodermal cells were made of the flagellated columnar epithelium. At the beginning of the free-living stage, the endodermal cells were packed with yolk granules. Differentiation of endodermal cells began at the time polyps developed oral openings and feeding began. The endoderm was divided into three regions based on cell type; a pharyngeal region with albumin glands and gland containing "pockets", special folds at the junction of the manubrium and tentacles, and cells at the bottom of the gastral pit containing vacuoles with food inclusions. Digestion in polyps was intracellular and extracellular in the gastral cavity. Nerve cells were present in the tentacles, adjacent to the muscle cells.

Raikova, E.V. 1961b. The development of male gonads and spermatogenesis in *Polypodium hydriforme*. *Tsitologiya* 3: 528-544.

Male gonads can develop in individuals that already may or may not have female gonads. Such observations made by culturing free-living polyps in microaquaria also showed that individuals in which female gonads developed, resorbed these structures after fulfilling their function and became male polyps. Normally four, but occasionally eight, male gonads formed by invaginations of the endoderm into the gastral cavity at the aboral end. Cells of the endodermal folds were identical to one another at first, but subsequently they differentiated into spermatogonia, which filled the cavity of the male gonads. During the diakinesis and metaphase I stages of the spermatogonia, there were 23 bivalents. At this stage, the gonads produced small cells, possibly feeder cells that adhered to the developing primary spermatophytes, and were later absorbed by the secondary spermatophytes. The first division formed a spermatocyte and a small reduction body that subsequently died. The second division did not end in cytokinesis and hence yielded one spermatid with two unequal nuclei. The binucleate spermatids, with special

ectodermal coverings, were released by the polyp into the external environment.

Raikova, E.V. 1963a. A cytomorphological study of female gonads of the coelenterate *Polypodium hydriforme* (Coelenterata). *Tsitologiya* 5: 391-403.

Two or four sexual complexes, each made up of two ovaries and two oviducts, constituted the female reproductive system of the *Polypodium hydriforme*. The oviducts opened into the gastral cavity. These structures were purely of endodermal origin. Hermaphroditism in polyps was transient, since female gonads degenerated immediately after formation of male gonads which continued to develop. The endodermal cells of the membrane covering the female sexual complex remained unchanged and identical to the endodermal cells of the gastral activity. The cells of the oviduct could be distinguished into two types; the thin generating cells forming the oogonia and the nutritive iron cells. The iron cells of the ovary contained secretory granules of protein cytoplasm with large polyploid nuclei. The oogonia in the ovarian cavity multiplied by mitosis and accumulated the secretory granules from the iron cells by absorption. The oogonia passed from the ovary, via the oviduct, to the gastral cavity. The fate of these oogonia remained unknown. In two cases, male sex cells had been found in the female gonads.

Raikova, E.V. 1963b. Morphological and cytochemical changes in the oocytes of the sterlet and the sturgeon induced by *Polypodium hydriforme* Ussov (Coelenterata). *Dokl. Akad. Nauk SSSR* 152: 985-988.

Polypodium was found in stages II-III of oocyte development in sturgeon and a comparison was given between uninfected and infected oocytes. In the infected ovum, the nucleus was misshapen and infected oocytes became enlarged. At this stage, there was more glycogen and yolk in the infected oocyte than in corresponding parts of healthy oocytes, whereas in stage IV of oocyte maturity, healthy ova had more glycogen than infected ones. The peripherally situated stolon of the parasite surrounded the yolk, which did not differentiate. Polarity was thus not achieved. The nucleus was deformed and the chromosomes were scarcely ever seen. Starting at the stolon stage, the oocyte nucleoli became enlarged, and

vacuolized, and remained hypertrophied until the spawning stage. RNA in the nuclei of infected oocytes was more firmly bound to protein. At stage IV, the fat was distributed evenly in the yolk, now at the centre. At stage V, the yolk was drawn out to form the gastral pouch of *Polypodium* and the nucleus was destroyed.

Raikova, E.V. 1964a. Early parasitic stages of the developmental cycle of *Polypodium hydriforme* Ussov (Coelenterata). Dokl. Akad. Nauk SSSR **154**: 742-743 (page numbers may be incorrect).

Sterlet ovaries in the II-III stage of maturation were sectioned and three fish were found infected. The earliest parasitic stage of *Polypodium* was found in oocytes measuring 0.33 mm in diameter and lacking yolk. The parasite consisted of a cluster of 22-23 cells lying in a cavity surrounded by a cellular envelope undergoing syncytial merging of cells (the capsule). In another case, the morula-like compact mass of cells measured 50 x 30 μ m and the capsule measured 110 μ m in diameter. In the third infected fish (stage II-III of gonad maturation), the parasite body was made up of a large number of cells, covered by a well-developed capsule. The early capsule formation was considered a long-standing adaptation to parasitism.

Raikova, E.V. 1964b. Unicellular parasitic stages in the life cycle of *Polypodium hydriforme* Ussov (Coelenterata). Dokl. Akad. Nauk SSSR **154**: 742-743 (page numbers may be incorrect).

Oocytes of *Acipenser ruthenus* measuring 100 μ m were found infected with early stages in the development of *Polypodium*. These were binucleate single cells with one large polyploid nucleus and one small nucleus. The large nucleus developed a deep invagination that engulfed the small nucleus. The large nucleus and a part of the cytoplasm formed a capsule around the remaining cytoplasm containing the small nucleus. The latter gave rise to the blastomeres. These binucleate early stages resembled the spermatids within the male gonads of the free living polyp stage.

Raikova, E.V. 1965. A cytomorphometric study of the DNA content in the cell nuclei of *Polypodium hydriforme* Ussov (Coelenterata) at various stages of its life cycle. Zh. Obshch. Biol. **26**: 546-552.

Diploid ectodermal and endodermal cells, studied by Feulgen cytophotometry, contained identical amounts of DNA. The small nuclei of both the binuclear spermatid (in male gonads) and the binuclear parasitic cell in sturgeon oocytes, contained half the DNA of somatic cell nuclei. Early embryogenesis in *Polypodium* was initiated without fertilization since cleaving blastomeres were haploid, but the diploid condition was regained later during development. The large nucleus of the spermatid, on the other hand was 4-6n, while that of the parasitic binuclear cell was 400n. Polyploid nuclei (8-32n) were also present in nurse cells of *Polypodium* ovaries. Gonads of the polyp stage of *Polypodium* released sex cells, which were polyploid, and these were thereafter thought to correspond to oogenesis.

Raikova, E.V. 1973. Life cycle and systematic position of *Polypodium hydriforme* Ussov (Coelenterata), a cnidarian parasite of the eggs of Acipenseridae, p. 165-173. In T. Tokoika and S. Nishimura (ed.) The Proceedings of the Second International Symposium on Cnidaria, Shirahama and Kushimoto, October 16-19, 1972. Seto Marine Biological Laboratory, Graduate School of Science, Kyoto University, Japan.

A review of the life cycle of this parasite was presented. The earliest investigated stage of the parasite, found in sterlet (*Acipenser ruthenus*) oocytes, was a one cell stage 20-30 μ m in diameter, with two unequal sized nuclei, a small haploid one and large polyploid one (up to 400 n). As the oocyte grew, the small nucleus, with some differentiating cytoplasm surrounding it, entered the deep cavity formed by the large nucleus, and later gave rise to the cleaving blastomeres of the embryo. The main mass of the binucleated cell along with the large nucleus formed a peculiar capsule around the parasite and carried out feeding functions. Cleavage of the polyploid nucleus into polymorphic nuclei led to the formation of compact morula. At vitellogenesis, the infected oocyte already had a two-layered, planula-like larva with inverted embryonic layers; the capsule surrounded the flagellated entoderm outside and the ectoderm inside. In August, the planula grew into the stolon stage and in winter the capsule degenerated. In spring, just before sturgeon spawning, the embryonic membranes of the stolons assumed the normal position by evertting. After spawning, the free-living stolons

separated into buds, and formed mature unisexual polyps with development of the first female and then male gonads, in addition to development of hermaphroditic individuals. The female sexual complex (1-8/polyp) was entirely endodermal in formation, including two sexual glands opening via gonoducts to the gastral cavity. The male gonads (4/polyp) had no gonoducts, and were also endodermally produced. After meiosis, cells had two unequal nuclei, the small nucleus was haploid while the larger one reached $4n$ by polyploidization. Such gonads fell out of polyps intact and cases were known where polyps actively attached such units to juvenile sturgeon. The fate of these female and male gonads was unknown as was the method of infection. Based on the unusual lifecycle and morphological features, *Polypodium* may deserve a separate class status within Cnidaria.

Raikova, E.V. 1978. Electron microscopical investigation of the nematocyst development in the parasitic stolon of *Polypodium hydriforme* Ussov (Coelenterata). *Tsitologiya* **20**: 384-386.

Primordia of large and small nematocysts appeared on the cytoplasm of the developing cnidoblasts as membrane-bound vacuoles containing granular material which later formed the nematocyst wall and a dense matrix. The outer surface of the wall of the developing nematocyst had a microtubule lining. As the nematocyst primordium elongated, an extracapsular tube, coated with a dense wall and lined with microtubules, developed in the cnidoblast cytoplasm and contained alternating dark and light portions of the matrix. The nematocyst enlarged and developed a corrugated hollow internal filament. The maturing nematocyst rounded up, its wall differentiated into two layers and its internal filament formed short barbs on it.

Raikova, E.V. 1980a. Morphology, ultrastructure and development of the parasitic larva and its surrounding trophamnion of *Polypodium hydriforme* Ussov (Coelenterata). *Cell Tissue Res.* **206**: 487-500.

Polypodium had a planuliform parasitic stage, with inverted germ layers, developing inside the oocytes of acipenserid fishes. The trophamnion was a compact layer of cytoplasm, 6-10 μ m thick, and characterized by microvilli on the inside, numerous prominent Golgi bodies,

ingested yolk platelets, and lysosome-like vesicles. Digestion and protections were likely functions of the trophamnion. Nutrition uptake appeared to be by phagocytosis of yolk by the trophamnion. Products of digestion were exocytosed into the parasite containing cavity to be absorbed by the endodermal cells. The trophamnion was now considered to be a giant hollow cell rather than a symplast as was previously thought (Raikova 1960b). Endodermal cells on the exterior of the larva were flagellated with basal vacuoles and a subapical nucleus. The cytoplasm was rich in ribosomes and polyribosomes, and contained many microtubules. Ectodermal cells were not ciliated (unlike other coelenterates) but, like endodermal cells, were vacuolated and contained large nuclei with well-developed nucleoli. The characteristic apical layer of acid mucopolysaccharides, absent in some larva, apparently formed during the planuliform stage. The cells of both layers occasionally interdigitated, and the lateral surfaces of endodermal cells had microtubules. The mesoglea, 0.5-1.5 μ m thick, had many 10 nm thick fibrils.

Raikova, E.V. 1980b. Trophical adaptations of *Polypodium hydriforme* Ussov on the larval stage, p. 92-95. In D.V. Naumov and S.D. Stephanyants (ed.) *The theoretical and practical importance of the coelenterates*. Akademiya Nauk SSSR, Leningrad.

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Raikova, E.V. 1984. Ultrastructure of the stolons of *Polypodium hydriforme* Ussov (Coelenterata) parasitic in oocytes of acipenserid fishes. *Monit. Zool. Ital.* **18**: 1-24.

The stolon of the parasitic coelenterate *Polypodium hydriforme* in the eggs of the sterlet and sturgeon was surrounded by a giant hollow cell called the trophamnion that lined the parasitophorous vacuole. This functioned as the feeding organ for the parasite. The trophamnion showed greatest trophic activity during August and September when it had many food inclusions and microvilli in the shape of a sieve. The trophamnion degenerated in May by fragmentation, pycnotisation of its nucleus and cytoplasmic degeneration. Following this, the endodermal cells which made up the outer layer due to inversion of the germ layers almost throughout stolon development, began

phagocytosing and became packed with yolk. Endodermal cells also differentiated into cells of the tentacle axis, feeding cells, and gland cells. Feeding cells had microvilli-like pseudopodia, and contained vesicles, and occasionally granular endoplasmic reticulum. The ectodermal cells differentiated into cnidocytes and epidermal cells. Golgi complexes within ectodermal cells produced numerous acid mucopolysaccharide granules which accumulated at their apical ends. Underlying the ectoderm were myocytes forming the muscle layer. Myofibrils lied adjacent to microtubules and consisted of both thick and thin protofilaments. Muscle cells contained a considerable amount of glycogen with intercalated disc type intercellular contact. Nerve cells were not found. Prominent among the differences with other coelenterates was the absence of muscle fibers in the endodermal cells, and the presence of muscle cells in the form of myocytes instead of the typical epitheliomuscular or digestive-muscular cells.

Raikova, E.V. 1985. Cytological paradoxes in the life cycle of *Polypodium hydriforme* - an intracellular parasite of oocytes of the acipenserid fishes. *Tsitologiya* 27: 391-401.

The embryonic development of the parasitic phase of the life cycle of *Polypodium hydriforme* was considered. Development of the parasite embryo took place parthenogenetically (without fertilization) and developed from aberrant binucleate gametes formed by meiosis within the gonads of free living stages. This type of gametogenesis was considered to be oogenesis [earlier considered as spermatogenesis (Raikova 1961)]. The gonads of free-living animals, which were earlier thought to be female, produced no mature sex cells and seemed to be abortive rudimentary organs. Adaptations to parasitism included a long-lasting block of cytokinesis of the second meiotic division and the utilization of the polar body of this division as a phorocyte, and later, as a trophamnion. *Polypodium* differed from other coelenterates in possessing polyploid feeding cells at the parasitic and free living phases of the life cycle.

Raikova, E.V. 1986. *Polypodium hydriforme* (Coelenterata) from the eggs of sturgeon from the Ural River. *Parazitologiya (Leningr.)* 20: 364-372.

Histological preparations were made of healthy and *Polypodium* infected oocytes of acipenserids caught in the Ural River. *Acipenser nudiiventris* and *Huso huso* were found infected with this parasite. The parasitic stages of *Polypodium* in the oocytes of these species as well as those of *Acipenser stellatus* were described for the first time. The development of this parasite precisely followed the stages of oogenesis within the host. Stolons with inverted germ layers were found in immature females while stolons with normally positioned germ layers were present in maturing hosts. A binucleate cell as an early stage of infection has been found in young generation of oocytes in *Acipenser nudiiventris*. Similar coordination of the parasite life-cycle with the stages of oocyte development, similar reactions of infected oocytes to the presence of the parasite, and similar sizes of cnidocysts of *Polypodium* occurring in oocytes of the three acipenserid species suggested that they were the same as the species found in the Volga.

Raikova, E.V. 1987. Peculiarities of the embryonic development of *Polypodium hydriforme* Ussov (Coelenterata), a parasite of acipenserid oocytes. *Gegenbaurs Morphol. Jahrb.* 133: 99-121.

One hundred and seven specimens of the unicellular stage and sixty-four specimens of the multicellular stage of *Polypodium* were recovered from the eggs of fourteen sterlet (*Acipenser ruthenus*). The parasitic stages were investigated by light microscopy, cytophotometry, and autoradiography following incubation with ^3H -uridine. The unicellular stage transformed to the bicellular and multicellular stage in the following pattern characterized by a binucleate cell with unequal-sized nuclei, development of a two-celled complex with the larger cell surrounding the smaller cell, formation of a cavity inside the larger cell-nucleus, and migration of the small cell into it. The large trophic cell surrounding the smaller generative cell gave rise to a hypertrophied but unicellular envelope around the parasite embryo - the trophamnion. The multicellular stage started with the segmentation of the generative cell into blastomeres. This resulted in a morula within the trophamnion cavity. The inversion of germ layers was apparently formed during gastrulation. Blastomeres were haploid and diploidy was restored during segmentation. As the trophamnion grew its cytoplasm

accumulated mucoprotein inclusions and the nucleus became highly polyploid. The blastomere nuclei and the trophamnion nuclei actively synthesized RNA. Although the embryonic development of *Polypodium* lasted several years and was the slowest among coelenterates, it had features typical of the class Hydrozoa.

Raikova, E.V. 1988. Embryonic stages of development of *Polypodium hydriforme* (Coelenterata) in oocytes of *Acipenser ruthenus*. *Parazitologiya* (Leningr.) **22**: 201-209.

In sterlet (*Acipenser ruthenus*) oocytes, 107 specimens of unicellular stages and 64 specimens of cleavage stages of *Polypodium* were studied by light microscopy. The developmental stages of the parasite corresponded to the oocyte maturation in the hosts. The embryonic development of *Polypodium* lasted several years and was probably the slowest developing and had the smallest eggs among the coelenterates. The eggs developed without fertilization within a nutritive cell called the trophamnion, which separated at the II meiotic division of the oocyte. Cleavage was total and the morula stage was long-lasting. Gastrulation occurred by morular delamination. The inversion of the germ layers was likely to take place at this time. The blastomeres and trophamnion had large nucleoli and actively synthesized RNA.

Raikova, E.V. 1994. Life cycle, cytology, and morphology of *Polypodium hydriforme*, a Coelenterate parasite of the eggs of Acipenseriform fishes. *J. Parasitol.* **80**: 1-22.

Polypodium hydriforme was listed as occurring in lake sturgeon in the Black, Nelson, and Saskatchewan rivers.

Raikova, E.V., Suppes, V.C., and Hoffman, G.L. 1979. The parasitic coelenterate *Polypodium hydriforme* Ussov, from the eggs of the American acipenseriform *Polyodon spatula*. *J. Parasitol.* **65**: 804-810.

Histological investigations of parasitic stolon and free-living polyps of *Polypodium* sp. obtained from *Polyodon spathula* eggs showed essentially the same features as those described from *Polypodium hydriforme* in the Volga sterlet (*Acipenser ruthenus*). Parasitic

stolons investigated were inside oocytes of stages IV and V. The acid mucopolysaccharide granules in the meshes of the reticulated apical cytoplasm of endodermal cells, common in Volga *Polypodium*, were not observed in the North American material. This had been attributed to the fixatives used in the study. The study indicated with a high degree of probability that the two *Polypodium* populations were one species.

Rathje, C. 2000. NYS Oneida fish hatchery lake sturgeon stocking, p. 16-17. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 6 April 2006].

Reed, E.B. 1962. Fish fauna and pollution, p. 29-33 & p. 41-46. In Limnology and fisheries of the Saskatchewan River in Saskatchewan. Saskatchewan Department of Natural Resources, Fisheries Branch Research Report No. 6.

One lake sturgeon was netted in the South Saskatchewan River and three in the Saskatchewan River. Large numbers of lake sturgeon were reported to occur in the South Saskatchewan River near its junction with the Red Deer River. Sturgeon were also reportedly plentiful at Maymont on the North Saskatchewan River, but had not been seen there for many years. Residents of Cumberland House commercially fished sturgeon from the South Saskatchewan and Torch rivers. The annual harvest averaged approximately 7,000 pounds over the previous 12 years.

Reeves, R.R., and Bunch, J.N. (ed.) 1993. Forum on science and resource-related issues in hydroelectric development. An unpublished report prepared for the Office on Energy Research and Development, Canada, Department of Energy, Mines and Resources, Ottawa, Ontario. vi + 37 p.

The results of a national forum held to examine science and resource related issues in hydroelectric development were detailed. The purpose was to provide information to the interdepartmental panel of the federal Program on Energy Research and Development (PERD)

regarding its involvement in determining environmental impacts of hydroelectric projects. The focus was on issues falling under three main headings: freshwater, estuarine, coastal and offshore, and cumulative effects. The following issues were agreed to be of greatest priority: mobilization and uptake of mercury and other heavy metals, fisheries sustainability, management of water levels, endangered species, sediment flux in estuaries, conservation of wetlands and floodplains, anadromous fish stock maintenance, and cumulative effects. Lake sturgeon were discussed on page 8 in relation to the proposed expansions of existing hydroelectric stations on the Mattagami River. Lake sturgeon are least vulnerable to entrainment in the spring because they are well upstream during the spring freshet. A list of participants and their associated contact information was included.

Reichenbach-Kilnke, H.H., and Elkam, E. 1965. Infectious diseases, p. 66-67. *In* The principle diseases of lower vertebrates. Academic Press, London and New York.

This item was not available for annotating.

Reiter, D., and Runstrom, A. 2004. Lake sturgeon on the Menominee Indian Reservation: an effort towards co-management and population restoration. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The construction of two dams on the Wolf River downstream from Keshena Falls in the late 19th and early 20th centuries contributed to the extirpation of lake sturgeon and affected the Menominee Nation through the loss of this culturally important species. Cooperation between resource management agencies and the public had resulted in a reintroduction of lake sturgeon in the Menominee Reservation in 1993. Preliminary results regarding habitat requirements, seasonal movements, stocking, dispersal, and reintroduction numbers of lake sturgeon in the reservation waters were discussed.

Remnant, R.A. 1995. A fisheries survey of the lower Churchill River mainstem, 1994. Unpublished report prepared by North/South Consultants Inc., Winnipeg, MB, for Manitoba Hydro. vii + 70 p.

This study examined the seasonal species composition, abundance, and size of fish using the lower Churchill River mainstem. One juvenile lake sturgeon was captured by gill net in the fall of 1994. It had a total length of 363 mm and was aged at 4 years. This was taken to indicate successful spawning in the lower Churchill River watershed.

Remnant, R.A., and Baker, R.F. 1993. Habitat classification and fish utilization of the lower Nelson River, 1992. An unpublished report prepared by North/South Consultants Inc., Winnipeg, MB, for Manitoba Hydro. vi + 106 p.

The objectives of this study were to classify fish habitat under the existing discharge regime of the Limestone Generating Station (G.S.) and to determine the seasonal abundance of fish in habitats along the 102 km unimpounded section of the lower Nelson River. Sampling by boat electrofishing occurred during the spring, summer and fall of 1992. A total of 5 lake sturgeon were caught; 3 in open channel habitat and 2 in open channel/exposed shoal habitat. Another 10 lake sturgeon were observed; 4 in open channel habitat, 1 in a tributary confluence, 1 in backwater habitat, 1 in exposed shoal habitat, 2 in submerged shoal habitat, and 1 in submerged/exposed shoal habitat. Modifications to the study were recommended to improve understanding of the effects of discharge regulation on fish and their habitat downstream of the Limestone G.S.

Remnant, R.A., and Kitch, I.H. 1996. Fish utilization and habitat classification of the lower Churchill River mainstem, 1995. Unpublished report prepared by North/South Consultants Inc., Winnipeg, MB, for Manitoba Hydro. ix + 135 p.

The objectives of this study were to classify aquatic habitat and to determine seasonal fish use of that habitat in the lower Churchill River mainstem. One lake sturgeon, with a total length of 504 mm, was captured in a gill net on June 23, 1995. This sturgeon was recaptured 10 km upstream on August 7, 1995. At the time of recapture, it had a total length of 540 mm. It was identified as an immature male and was aged at 8 years.

Research Foundation of State University of New York (R.G. Werner - Principle Investigator). Date unknown. Contributing factors in habitat selection by lake sturgeon (*Acipenser*

fulvescens). Final report. Submitted to United States Environmental Protection Agency - Great Lakes National Program Office, Chicago, IL. iv + 19 p. Available from <http://www.epa.gov/glnpo/ecopage/glbld/LkSturgeon.pdf> [accessed 7 April 2006].

This study examined the diet of different size classes of lake sturgeon in the St. Lawrence River near the St. Lawrence FDR Power project. Shifts in prey preference related to body size and the prevalence of exotic Dreissenid mussels in lake sturgeon diet were studied. Habitat differences between juveniles and adults with regard to prey items were also examined. Summer sampling resulted in the capture of 25 lake sturgeon in each of the three target size classes (300-650 mm, 651-1,001 mm, 1,002-1,352 mm and larger). These sturgeon ranged in size from 341 mm to 1,498 mm total length. Twenty-five sturgeon from each size class were also caught in fall. These ranged in length from 354 mm to 1,604 mm. In summer, the dominant prey items in the smallest size class were Chironomidae (72.9%) and Gammaridae (17.9%). In the middle class the dominant prey items were Gammaridae (59.7%) and Chironomidae (22.8%). Dreissenid mussels accounted for 4.6% of all prey items. In the largest size class, Dreissenid mussels were the most common prey (73.5%) followed by Gastropods (16.7%). In the fall, the dominant prey items of the smallest size class were Gammaridae (80.9%) and Chironomidae (16.6%). In the medium size class Gammaridae (60.3%) and Chironomidae (25.3%) were dominant. Dreissenid mussels made up 11.6% of the hard shell prey items. Dreissenid mussels were the dominant prey of the large size class (65.2%) followed by Gammaridae (17%). The dominant substrate of juvenile habitat was silt (65.4%), followed by boulders (23.7%) and cobble (6.9%). The dominant substrate of adult habitat was boulders (51.5%), followed by silt (29.5%), large cobble (12%), small cobble (4%), and coarse sand (3%). Macroinvertebrate sampling was completed in both juvenile and adult habitats. A shift in diet related to size was revealed, as well as a shift in habitat preference related to prey availability.

Rich, C. 1987. Spawning assessment of lake sturgeon at Whist Falls and La Duke Rapids on the Groundhog River. Ont. Min. Nat. Res. Tech. Rep. 10 p.

This document was not available for annotating.

Riser, N.W. 1948. *Amphilina bipunctata*, n. sp. A North American cestodarian. J. Parasitol. 6: 479-485.

Specimens of a previously undescribed species of cestodarian were recovered from a jar labeled Trematoda with a label that stated that these were collected from the coelom of a "sturgeon" from Dodson, Oregon, in 1923. The cestodarian was named *Amphilina bipunctata* and described as having the following salient morphological features: length of larger specimens >50 mm, small apical organ, 350-400 testes between vitellaria and uterine coils, anastomosing vasa efferentia, coiled vas deferens, pyriform bulbous propulsorius 0.97-1.05 mm long, divided lateral vitellaria, small compact and lobed ovary, posteriorly attenuated well developed Mehlis gland with ascending and descending loops on the same side, uterine pore terminal, seminal receptacle 0.51-0.79 mm long x 0.36-0.150 mm in diameter, vaginal pore 0.04-0.07 mm lateral to the male papilla, and eggs oval 0.112-0.150 mm long x 0.059-0.075 mm in maximum diameter. It was compared to existing species *A. foliacea* and *A. japonica* and found to be morphologically closer to *A. japonica*.

Robinson, M., and Ferguson, M. 2001. Lake sturgeon population genetics in the Saskatchewan and Winnipeg rivers. Submitted to Fisheries Branch, Manitoba Conservation and SERM Fish and Wildlife Branch, Saskatchewan. 13 p.

To determine whether their lake sturgeon populations could be distinguished using microsatellite DNA markers, samples were taken from river systems in Manitoba, Saskatchewan, and Ontario in spring, summer and fall of 2000. Genomic DNA was isolated from fin tissues using a phenol/chloroform extraction procedure. Three microsatellite loci were amplified by the polymerase chain reaction from each of 330 individuals. Population samples were compared to one another and tested for significant differences using three pairwise tests. The microsatellite loci analyzed showed a high degree of polymorphism. The significant genetic differences found between lake sturgeon populations in the Rainy, Saskatchewan, Winnipeg, and Nelson river systems revealed unique genetic stocks in each of the rivers. Conservation and rehabilitation efforts should

not involve the transfer of fish or gametes from one river system to another, and they should be managed as separate stocks.

Robison, H.W. 1974. New distributional records of some Arkansas fishes with addition of three species to the state ichthyofauna. *Southwest Nat.* **19**: 220-223.

The lake sturgeon was reported in Arkansas for the first time. Mr. Kenneth Walsh captured a 135 pound sturgeon using hook and line. The fish was taken in July from the Little Missouri River near Chidester, Ouachita County.

Robitaille, J.A., Choiniere, L., and Vigneault, Y. 1991. Identification des populations de poissons d'intérêt économique en situation précaire dans le réseau du St-Laurent et sélection des espèces pour des interventions immédiates. Rapport technique canadien des sciences halieutiques et aquatiques **1810**: ix + 24 p.

Lake sturgeon were identified as being vulnerable and the priority order of intervention for habitat restoration and stock recovery was suggested.

Robitaille, J.A., Vigneault, Y., Shooner, G., Pomerleau, C., and Mailhot, Y. 1988. Modifications physiques de l'habitat du poisson dans le Saint-Laurent de 1945 à 1984 et effets sur les pêches commerciales. Rapp. tech. can. sci. halieut. aquat. **1608**: v + 45 p.

Landings from the freshwater fishery and changes to aquatic habitat along the St. Lawrence Seaway between 1945 and 1984 were described. It was impossible to directly link the decline in commercial catches with pollution, shoreline development, and water regulation, although it was believed that dredging and shipping operations in the mid-'50s were the most important disturbances. Anthropogenic changes related to shipping are thought to have had the greatest impact on fisheries and migrating fish stocks in the tidal areas of the St. Lawrence Seaway. Lake sturgeon was one of the most important fish species in the commercial harvest. Total combined catches from the St. Lawrence Seaway at Montréal, Boucherville-Sorel, Saint-Pierre Lake, downstream from Trois Rivières, Québec-Lévis and the estuary dropped from over 100 tonnes in 1945 to below 20 tonnes in 1952, peaking

between 1958 and 1966, then dropping to well below 20 tonnes with a gradual rise to the current level (approximately 50 tonnes).

Rochard, E., Castelnau, G., and Lepage, M. 1990. Sturgeons (Pisces: Acipenseridae): threats and prospects. *J. Fish Biol.* **37**: 123-132.

The biology and conservation status of the world sturgeon species were reviewed and various measures to compensate for negative impacts on sturgeon were discussed. In Canada, sport fishing for lake sturgeon was described as being popular, and its commercial fishery was described as "intense". Fishing regulations in Canada were cited and these regulations were reported as being apparently effective (the authors quoted Dumont et al. 1987, see in this bibliography).

Rochard, E., Williot, P., Castelnau, G., and LePage, M. 1991. Éléments de systématique et de biologie des populations sauvages d'esturgeons, p. 475-507. In P. Williot (ed.) *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989. Bordeaux, France.

Systematic, biological and ecological data were presented for 24 sturgeon species of which 17 were *Acipenser*, 2 *Huso*, 3 *Pseudoscaphirhynchus* and 2 *Scaphirhynchus*.

Rosenberg, D.M., Berkes, F., Bodaly, R.A., Hecky, R.E., Kelly, C.A., and Rudd, J.W.M. 1997. Large-scale impacts of hydroelectric development. *Environ. Rev.* **5**: 27-54.

This review examined four impacts of hydroelectric developments, namely, methylmercury bioaccumulation, emissions of greenhouse gases, downstream effects, and limitation of biodiversity. Lake sturgeon from the Moose River system, Ontario were mentioned in Table 7 on page 43. The low lake sturgeon populations in the Mattagami River were likely due to commercial overharvesting and negative effects on spawning caused by water-level fluctuations from power generation. Low water-levels after spawning expose eggs to variable water temperatures, low oxygen concentrations, and desiccation. Fry may become trapped in shallow pools which makes them vulnerable to predation and exposes them to high

temperatures and oxygen depletion. Other sturgeon species mentioned included white sturgeon (*Acipenser transmontanus*), Chinese sturgeon (*A. sinensis*), and *A. sturio*.

Rosenthal, H. 2003. World Sturgeon Conservation Society E.V. (WSCS). J. Appl. Ichthyol. 19: 343.

This notice described the newly formed World Sturgeon Conservation Society, which stemmed from two international symposia held on sturgeon, the first in Italy in 1997 and the second in Wisconsin in 2001. The focus of this group was to provide an international forum for scientific discussion and co-operation for people interested in sturgeon species. It would promote the exchange of information, foster conservation and restoration of sturgeon populations on a global scale, foster continuing research, and inform the public on the status, biology, and management of sturgeon.

Ross, R.M., and Bennett, R.M. 1997. Comparative behavior and dietary effects in early life phases of American sturgeons. Fish. Manag. Ecol. 4: 17-30.

Larvae and juvenile shovelnose, Atlantic, and lake sturgeon were studied to determine effects of diet and development on swimming and foraging behaviour, as well as depth distribution in aquaria. Scouring behavior of early juvenile lake sturgeon differed among different diet types. Developmental effects included early peaks in the performance of swim-up for all species. Post-larval lake sturgeon maintained bottom swimming with increased scouring activity.

Rossiter, A., Noakes, D.L.G., and Beamish, F.W.H. 1995. Validation of age estimation for lake sturgeon. Trans. Am. Fish. Soc. 124: 777-781.

Lake sturgeon were aged by counting annuli in transverse sections of pectoral fins. The first ray of the right pectoral fin was removed upon first capture. One to three years later they were recaptured and the first ray of the left pectoral fin was removed. Differences in annuli from capture to recapture were equal to the number of years between sampling. Fin rays that were previously injected with oxytetracycline (OTC) exhibited a fluorescent band under UV light. The number of annuli outside of the OTC marker were equal to

the number of years between capture and recapture. Caution must be taken when determining age because some annuli were so close together that two annuli could be counted as one, resulting in an underestimation of age.

Rousseaux, C.G., Branchaud, A., and Spear, P.A. 1993. Evaluation of liver histopathology in St. Lawrence lake sturgeon (*Acipenser fulvescens*) collected from their spawning site, p. 285. In 14th Annual Meeting (SETAC) - Ecological Risk Assessment: Lessons Learned? Abstract Book. [Abstract only].

Rousseaux, C.G., Branchaud, A., and Spear, P.A. 1995. Evaluation of liver histopathology and EROD activity in St. Lawrence lake sturgeon (*Acipenser fulvescens*) in comparison with a reference population. Environ. Toxicol. Chem. 14: 843-849.

Lake sturgeon were sampled from Rivière des Prairies and at a reference site on the upper reaches of the Ottawa River. Sections of liver taken from the Rivière des Prairies site showed excessive fat accumulation and frequently severe chronic active cholangiohepatitis. Bile duct proliferation, periportal fibrosis, inflammation, and fat accumulation were more pronounced in sturgeon from Rivière des Prairies. Melanomacrophage centers were paler and gave the appearance of fewer numbers. Livers taken from the reference site appeared more normal. EROD levels were found to positively correlate with bile duct proliferation and periportal fibrosis, but could not be stated as the only cause of the lesions observed.

Roussow, G. 1955a. Les esturgeons du fleuve Saint Laurent en comparaison avec les autres espèces d'acipenserides. Pêche, Biométrie, Croissance, Age, Migration, Pisciculture. Contribution de L'office de Biologie No. A36, Ministère Chasse et Pêcherie, Province de Québec. 124 p.

This Ph.D. thesis reviewed the literature of sturgeon worldwide (especially Romania and the USSR, including Siberia) and compared it with the sturgeon of the St. Lawrence River. There was a description of the key morphological measurements that were usually done on sturgeon and a description of aging methods, including a photograph and a diagram of a section through the pectoral fin ray. Chapter 2 contained an interesting description of fishing for

sturgeon on the St. Lawrence River and detailed fishing methods on the Danube River in Europe, including how to set up baited hook lines. There were photographs illustrating barriers that were set up to stop the migration of sturgeon in Russia, and of methods for fishing through the ice using long handled curved hook harpoons. There was a discussion on the preparation of industrial products such as caviar, smoked filets, and glue, as well as the treatment of swimbladders and salted heads. Seven hundred and fifty sturgeon were collected and 237 individuals were marked and recaptured. The average age of females was 11.59 years and for male, 11.63 years. A frequency distribution of age was shown graphically with ages ranging from 2 to 30 years. Graphical comparisons of growth variables were made for *A. fulvescens* from Lake St. Francois, Lake St. Pierre, and Lake Nipigon, *A. baeri* from the Irtych River, *A. gueldenstaedti* from the Volga, and *A. baeri* from the Enissei. A detailed map was given of the St. Lawrence River showing sites of capture and marking and recaptures. There was an extensive discussion of the artificial culture of sturgeon, and diagrams illustrating collection and incubation of fertilized eggs and early stages of embryonic development.

Roussow, G. 1955b. Quelques observations sur les variations de forme et de couleur chez les esturgeons de la province de Québec. Ann. ACFAS (Assoc. Can. Fr. Av. Sci.) **21**: 79-85.

This document was not available for annotating.

Roussow, G. 1957. Some considerations concerning sturgeon spawning periodicity. J. Fish. Res. Board Can. **14**: 553-572.

Cross-sections of the leading marginal pectoral fin ray were examined for information on the spawning periodicity of lake sturgeon. The length, weight, age, and state of gonads of 175 females and 164 males examined, as well as other field observations, indicated that: sturgeon moved upstream to spawn in mixed groups consisting of individuals in different stages of maturity and of different ages, and sizes; the male-female ratio was about equal; spawning took place between the end of May and first three weeks of June; and temperatures varied from 9-18°C. Two morphs of lake sturgeon (*Acipenser fulvescens acutirostris* and *A. f. obtusirostris*) were found in the catch but did not differ in age and maturity. Cross-sections of the

leading pectoral fin ray revealed age, growth during favorable and unfavorable periods in terms of particular years, age of first reproduction (maturity), sex, and intervals between spawning periods. The logic and methods behind these interpretations were discussed. Periods of slow growth were manifested in closely spaced annuli. This could indicate a post-spawning recuperation period or a period of slow growth preceding spawning. From detailed examination of the state of the gonads and corresponding fin-ray sections of 17 sturgeon, the latter was found to be true. Fish without such belts of annuli were considered immature and the nature of these belts gave information on the stage of the gonads and whether a female was a first time spawner. The females matured and spawned at 14-23 years of age (average 18 years) with a 7-9 year spawning periodicity. Males matured at age 9-13 and spawned at 15-19 years, with a spawning periodicity of 7 years. In a sample of sturgeon from spawning sites, 4% of the females and 20% of the males were in a ripe and running condition indicating the females had a considerably shorter period of oviposition. The age-length graph of female and male sturgeon from the Ottawa River indicated alternate slow and fast growth periods in the life history. Drawings showed the various stages of oocyte maturation in sturgeon.

Roussow, G. 1960. Quelques anomalies de gonads chez l'esturgeon de lac (*Acipenser fulvescens* Rafinesque) du Nord de la province de Québec. J. Board Off. Biol. Min. Chas. Pêch. **2**: 319-323.

One form of egg degeneration was called cement and consisted of a grayish liquid in which the remainder of the decomposing eggs were floating. The second anomaly consisted of ovarian cysts, which were grape-like in appearance. Cysts on the testes were also noted on two sturgeon. Photographs illustrated the anomalies.

Roy, D. 1989. Physical and biological factors affecting the distribution and abundance of fishes in rivers flowing into James Bay and Hudson Bay, p. 159-171. In D.P. Dodge (ed.) Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. **106**.

In northern Québec, lake sturgeon were not generally found north of the La Grande River. The number of lake sturgeon caught per year per fisher for the period 1976-77 by community was 0.6 for Rupert, 1.7 for Eastmain, 0.7 for Wemindji, and 0.8 for Chisasibi.

Royer, L.M., Atton, F.M., and Cuerrier, J.P. 1968. Age and growth of lake sturgeon in the Saskatchewan River delta. *J. Fish. Res. Board Can.* **25**: 1511-1516.

The age composition of 127 sturgeon collected over 4 years from the commercial operation at Cumberland House, Saskatchewan was described. Ages ranged from 1-65 years (one 70 lb sturgeon was recorded from the Saskatchewan Delta during the study). The data suggested that males grew more slowly than females at least beyond age 35. The Saskatchewan River population was considerably faster growing than the Nelson River or the Waswanipi Lake and River populations, but grew slower than the Winnebago (Wisconsin) population. Average annual increment in growth until age 20 was 2.1 inches fork length and 0.9 lb round weight. From age 20-40 the growth rate was 0.5 inches and 1.3 lb per year and beyond 40 years the growth rate decreased to 0.3 inches with a concomitant increase in weight to 1.4 lb. The length-weight relationship was expressed by $\log W = -4.02743 + 3.26445 \log L$, where W is round weight in pounds and L is fork length in inches. The largest sturgeon ever taken from the Saskatchewan River was a female caught on hook and line at Saskatoon, measuring a little over 6 feet and weighing 270 pounds.

Runstrom, A. 2003. Lake sturgeon reintroduction on Menominee Indian Reservation. La Crosse FRO Accomplishment Highlights Report. United States Fish & Wildlife Service. **October**: 4. Available from <http://www.fws.gov/midwest/LaCrosseFisheries/publications/index.html> [accessed 6 April 2006].

This short article discussed lake sturgeon restoration efforts on the Menominee Indian Reservation, Wisconsin. Lake sturgeon were extirpated in this area in the early 1900s due to the construction of two dams. Restoration efforts have been ongoing since 1995. Lake sturgeon are captured downstream from the dams, tagged with radio transmitters, and reintroduced into the Wolf River upstream of the dams. A total

of 151 sturgeon had been reintroduced at the time of writing, and more than half of them had migrated downstream.

Runstrom, A.L., and Reiter, D. 1997. Lake sturgeon (*Acipenser fulvescens*) on the Menominee Indian Reservation: an effort toward co-management and population restoration, p. 450. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Runstrom, A., Bruch, R.M., Reiter, D., and Cox, D. 2002. Lake sturgeon (*Acipenser fulvescens*) on the Menominee Indian Reservation: an effort toward co-management and population restoration. *J. Appl. Ichthyol.* **18**: 481-485.

Lake sturgeon were culturally important to the Menominee Nation, a Native American tribe of northeast Wisconsin. The fish historically migrated up the Wolf River to spawn at Keshena Falls, where the Menominee used to gather to harvest lake sturgeon each spring. This species has since been extirpated from the reservation due to the construction of hydroelectric facilities on the Wolf River downstream of Keshena Falls. Since 1932, the public has been able to harvest lake sturgeon by spearing during the winter months. All involved, including the Menominee people, voiced their concerns regarding the status of lake sturgeon in the area and in 1993, tribal, state, and federal representatives created a plan to reintroduce lake sturgeon to the Menominee Reservation. The Menominee Reservation Lake Sturgeon Enhancement Committee worked with various groups to outline common sturgeon restoration goals among often conflicting group interests. Since 1994, over 30,000 hatchery-raised lake sturgeon have been stocked in reservation lakes in addition to 87 Wolf River lake sturgeon being radio-tagged and relocated upstream to reservation waters of the river. Spawning occurred for the first time in 50 years in 2001. The success of the program to date and the participants' continual commitment to rehabilitating the lake sturgeon populations in reservation waters was encouraging.

Rusak, J.A., and Mosindy, T. 1997. Seasonal movements of lake sturgeon in Lake of the Woods and the Rainy River, Ontario. *Can. J. Zool.* **74**: 383-395.

Radio transmitters were implanted in 26 lake sturgeon inhabiting the southern portion of Lake of the Woods and the Rainy River. This study examined seasonal movement patterns, particularly spawning migrations, and habitat use. Data collected over a 3-year period suggested that there were two discrete sturgeon populations in the watershed with different seasonal habitat use, movement patterns, and rates and timing of spawning. The "lake" population showed consistent preference for lentic winter habitat and initiated extensive spring and summer movements later when compared to the "river" population, which inhabited the river during the winter. During the spring and summer, movements were the greatest, and they decreased with water temperature. Habitat preferences at different times of the year appeared to be related to foraging behavior. These results should be taken into consideration when planning management practices in large lake-river systems.

Ryder, R.A., Scott, W.B., and Crossman, E.J. 1964. p. 3-8. In *Fishes of northern Ontario*, north of the Albany River. Royal Ontario Museum, University of Toronto, Life Sciences Contribution No. 60.

The distribution of lake sturgeon was mentioned in brief among other species of fish known to occur in northern Ontario. A table of the distribution of fish species by collection site and major watersheds in the Patricia portion of Ontario and on Akimiski Island, in James Bay, was provided.

Saliaieva, E.V. 1957. Studies on *Polypodium hydriforme* - a parasite of acipenserid eggs, its biology and epizootological importance. *Sovesch po bolezniam ryb*, 22-27 goda. Izd. Akad. Nauk. SSSR. Moscow - Leningrad. Pagination unknown.

This item was not available for annotating.

Sandilands, A.P. 1987. Biology of the lake sturgeon (*Acipenser fulvescens*) in the Kenogami River, Ontario, p. 33-46. In C. H. Oliver (ed.) *Proceedings of a Workshop on the Lake Sturgeon (Acipenser fulvescens)*. Ont. Fish. Tech. Rep. Ser. 23.

A mark recapture study of lake sturgeon in the Kenogami River, Ontario, found that estimates

of biomass and density varied among three stretches of the river, with biomass being least for the Kapeesawatan Lake stretch (6.0 kg/hectare). Differences were attributed to habitat preferences and interspecific competition. Of the four other bottom feeding fish species examined, only the shorthead redhorse appeared to be a significant competitor. The age of fish caught ranged from 2 to 60 years; sex determination was not possible until 6-15 years of age. The youngest female close to maturity was 31 years old while the youngest maturing male was 20 years old. The maximum movement exhibited by a sturgeon in this study was downstream almost 150 km in 113 days. Mortality of sturgeon increased after age 45. The annual mortality rate of the total population was estimated at 4.6%. The diet of sturgeon was almost entirely invertebrates, of which crayfish was the predominant food item by volume (71.8%). Molluscs comprised only 10.5% of the food eaten and the remaining food items were aquatic insects (dragonflies, caddisflies etc.). There were no commercial licenses on this river and only subsistence fishing by natives was practiced.

Saskatchewan River Sturgeon Management Board. Date unknown. Saskatchewan River Sturgeon Management Board. [Booklet]. 11 p.

The role of the Saskatchewan River Sturgeon Management Board, the life history of lake sturgeon, monitoring efforts, the ten-year management plan, stocking were discussed.

Sathyanesan, A.G., and Chavin, W. 1967. Hypothalamo-hypophyseal neurosecretory system in the primitive actinopterygian fishes (*Holostei* and *Chondrostei*). *Acta Anat.* 68: 284-299.

In lake sturgeon, the infundibular canal penetrated the neurohypophysis and reached the lumen of saccus vasculosus indicating the close proximity of the pituitary to the saccus vasculosus. Two types of neurosecretory nuclei were present, in contrast to other acipenserids studied. The preoptico-hypophyseal axonal tract was divisible into two parts and the various regions were described by histochemistry. The nucleus lateralis tuberis (NLT) was distinct in the lake sturgeon in contrast to other acipenserids studied. The morphology of this nucleus suggested that its products may have directly

entered the hypothalamic blood vessels, the third ventricle, or been directed toward the pituitary.

Sato, C.S., and Gyorkey, F. 1976. Zinc binding by glycosaminoglycans. *J. Biochem.* **80**: 883-886.

Seven glycosamino glycans (GAG) were used in the experiments of which one standard was chondroitin 4-sulphate (C4S) from "rock sturgeon" (lake sturgeon) notochord tissue. Gel filtration of the solution containing ^{65}Zn and the GAGs gave similar results for all GAGs; only the first of the two peaks contained the GAG. C4S bound more zinc at pH 4.0 than at pH 7.0.

Sato, K., Yoshinaka, R., Itoh, Y., and Sato, M. 1989. Molecular species of collagen in fish - intramuscular connective tissue of fish. *Comp. Biochem. Physiol.* **92B**: 87-97.

This study had four major findings. First, the major collagen of intramuscular connective tissue of carp, lizardfish, Japanese eel, sturgeon, and spotted shark was Type I. Second, the major collagen of lamprey intramuscular connective tissue was different from the Type I collagen of lamprey skin and similar to invertebrate muscle collagen. Third, Type III-like collagen was not found in the species studied. Lastly, Type V collagen was distributed throughout the intramuscular connective tissue of the species studied. It conserved its amino composition during evolution from cyclostome to mammals more closely when compared to Type I collagen.

Saunders, D.A. 1981. Recommendations on the Mattagami River sturgeon fishery. Ontario Ministry of Natural Resources, Cochrane District, MS. Rep. 46 p.

Recommendations for the management of lake sturgeon in the Mattagami River were outlined and factors affecting the fishery such as dams, manipulation of water flows, and pollution were discussed. Estimates of lengths and ages of sturgeon by first spawning from the Mattagami River were made from data collected from the Onakanwana study. Males were 76-96.5 cm total length and 14-22 years of age and females were 84-96.5 cm total length and 17-22 years of age. The physical characteristics of the river (size, depth, presence of rapids, shoals and riffles), available food for sturgeon, and commercial catches suggested there was a

somewhat stable population. A tag and release program was recommended to determine populations and it was suggested that the commercial fishers should record data on length and weight, collect fin rays for aging, and preserve gonads in formalin. It was also recommended that commercial trap nets be considered as undesirable.

Saunders, E.J. 2006. Lake sturgeon in Alberta: a summary of current knowledge. Prepared for Fish and Wildlife Division, Alberta Sustainable Resource Development, Lethbridge, Alberta. 22 p.

This report summarized lake sturgeon research in Alberta and examined their distribution, foraging, reproduction, movements, habitat, population estimates, regulations and harvesting, and conservation concerns. A summary of results from annual questionnaires mailed to sturgeon angling license holders from 1968-2004 was included. Conservation concerns expressed included dam construction, water flow regulation structures, industrial disturbances, water quality, and contaminants. Appendix D contained an annotated bibliography of sturgeon references relating to Alberta; 14 references were included.

Scheidegger, K.J. 1997. The R's of managing Wisconsin's hook and line sturgeon fishery: registering, regulating, relocating, and revitalizing, p. 443. *In* 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Scheirer, J. 2002. Cooperative fisheries research on the East Fork of the Chippewa River seeks to answer questions about fish movement above Snaptail Rapids dam. Wisconsin Department of Natural Resources, Park Falls, Wisconsin. 7 p. Available from <http://basineducation.uwex.edu/upperchip/docs/eastfork.pdf> [accessed 7 April 2006].

A study examining movements of lake sturgeon in the East Fork of the Chippewa River was discussed. It was undertaken as part of a study to examine the effects of hydropower generation on fish, habitat, and angling. The study included temperature monitoring, fish capture, tagging, tracking, and habitat mapping. Preliminary tracking results were briefly discussed.

Schlueter, S. 2000. Oswegatchie River lake sturgeon restoration project, p. 10-12. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 6 April 2006].

Schneberger, E., and Woodbury, L.A. 1944. The lake sturgeon, *Acipenser fulvescens* Rafinesque in Lake Winnebago, Wisconsin. Trans. Wis. Acad. Sci. Arts Lett. **36**: 131-140.

This study reported on a creel census for sturgeon fishing on Lake Winnebago over the seasons of 1941, 1942 and 1943. Fishers were issued cards for length, weight, and other data. Despite limitations and the possible reluctance of fishers to share the knowledge of their success, 49 heads and 11 alimentary tracts were collected. A total of 788, 467 and 238 fish were caught in 1941, 1942 and 1943, respectively. The number of people reporting catches increased from 19.5% in 1941 to 66.3% in 1943, although the number of people purchasing such tags almost halved and the average number of sturgeon per fisher also decreased from 0.95 to 0.53. The number of fish per person reported caught varied from 0-5. Fish ranged in age from 14-40 years, in length from 47-62", and in weight from 28-81 pounds. During February, the sturgeon had fed mostly on chironomid larvae and were relatively free of parasites.

Schneeberger, P.J., Elliott, R.F., Jonas, J.L., and Hart, S. 2005. Benthivores, p. 59-73. In M.E. Holey and T.N. Trudeau (ed.) The state of Lake Michigan in 2000. Prepared for the Lake Michigan Committee. Gr. Lakes Fish. Comm. Spec. Publ. **05-01**. Available from www.glfc.org/pubs/SpecialPubs/Sp05_1.pdf [accessed 7 April 2006].

This chapter examined lake whitefish, round whitefish, lake sturgeon, and burbot in Lake Michigan. Lake sturgeon were discussed on pages 64-70. The lake sturgeon was considered rare, endangered, threatened, or of watch or special concern status by the various management agencies. Its harvest from Lake Michigan and its tributaries was banned or highly limited. At writing, lake sturgeon were

known to be present in 14 Lake Michigan tributaries, including the Fox, Oconto, Peshtigo, Menominee, Escanaba, Manistique, Millecoquins, Manistee, Muskegon, Grand, Kalamazoo, and St. Joseph rivers; Wolf Lake; and Ludington Shoal. Initiatives underway to enhance lake sturgeon rehabilitation were discussed.

Scholl, D.K. 1986. Lake sturgeon in the upper North Fork Flambeau River. Wis. Dept. Nat. Res., MS. Rep. 8 p. + tables, figures.

The sturgeon population of an 18 mile stretch of the upper north fork of the Flambeau River was studied to collect baseline data on various biological characteristics. Of the 115 sturgeon caught, 78 were electrofished and the rest netted. Sturgeon were first sighted in the rapids of the Upper Park Falls Dam when the water temperature reached 48°F and highest catches occurred during May 14-16 with water temperatures of 52-54°F and may have indicated a spawning peak. Six-inch gillnets were the most efficient in capturing legal-sized fish (45 inches total length and above). The weight-length relationship was expressed by the equation $\text{Log } W = -4.18 + 3.29 \text{ Log } L$, where W is weight in pounds and L is total length in inches. Sturgeon ranged in age from 8-40 years. The Flambeau River population was the slowest growing compared to Lake Winnebago, Yellow Lake, and Menominee River populations (45" in 23-24 years compared to 10 years in Lake Winnebago). A creel survey revealed that most of the fishing pressure (86%) occurred in September. The projected total sturgeon catch for the 1986 season was 343 fish (all sizes) and an average harvest of eight fish. The average sturgeon harvest from 1983-1985 was 17.3 fish. Caution was recommended in fishing this population due to its slow growth characteristics, but there was no evidence that overharvesting was occurring.

Schram, S.T. 2004. Lake sturgeon rehabilitation in western Lake Superior. In Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

The stocking of lake sturgeon in the St. Louis River had been largely successful. Fish were released from 1983 to 2000, representing 14 different age classes. Fish abundance in assessment nets and the recapture of marked

fish showed a high rate of survival. Fish were usually found in less than 30 meters of water and ranged 65 km from the mouth of the St. Louis River to Bark Point. It appeared that lake sturgeon had established a home area in western Lake Superior with adults returning to the St. Louis River spawning grounds.

Schram, S.T., Lindgren, J., and Evrard, L. 1997. Survival, growth and distribution of stocked lake sturgeon in the St. Louis River and western Lake Superior, p. 447. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Schram, S.T., Lindgren, J., and Evrard, L.M. 1999. Reintroduction of lake sturgeon in the St. Louis River, western Lake Superior. *N. Am. J. Fish. Manag.* **19**: 815-823.

Water quality of the St. Louis River has improved in recent years, while in upper-estuary spawning habitat it has remained about the same and sufficient for sturgeon spawning. The river had been stocked with sturgeon annually since 1983. Marked fish from the St. Louis River estuary and western Lake Superior were sampled to determine relative abundance, distribution, and growth. Lake sturgeon were repeatedly sampled near channelized portions of the St. Louis River, usually staying in the estuary for about 5 years before entering Lake Superior. Lake sturgeon were abundant in western Lake Superior, and 94% of all fish caught between 1985 and 1998 were in less than 30 meters of water. Stocking of the St. Louis River appears to have been successful. The authors recommended that the river continue to be stocked with 20-year classes and that Lake Superior be used as an egg source.

Schug, M.D., Porter, B., Fuerst, P.A., Parker, P., and Cavender, T.M. 1994. Molecular genetic differentiation between natural and stock populations of endangered lake sturgeon (*Acipenser fulvescens*) revealed using VNTR DNA markers. 103rd Annual Meeting of the Ohio Academy of Science. *Ohio J. Sci.* **94**: 27-28. [Abstract only].

Lake sturgeon were considered endangered in Ohio. In an effort to rehabilitate sturgeon, a stocking program had been initiated by the Ohio Department of Natural Resources using fish

from Wisconsin. Rapidly evolving VNTR loci were analyzed from 5 wild fish and 5 fish from a stock population. An average of 41 bands were scored per individual. Genetic similarity indices within the natural population were studied using a Jeffery's 33.15 VNTR probe 0.54 ± 0.08 and 0.23 ± 0.12 using a M13 VNTR probe. Equivalent values amongst stock populations were 0.86 ± 0.06 and 0.51 ± 0.08 . Genetic similarity indices for the two probes between natural and stock populations were 0.44 ± 0.1 and 0.19 ± 0.06 . Results showed that individuals in the stock population were closely related and should not be used as the sole source of stock to be reintroduced to natural populations in Lake Erie.

Schultz, I.R., and Hayton, W.L. 1999. Interspecies scaling of the bioaccumulation of lipophilic xenobiotics in fish: an example using trifluralin. *Environ. Toxicol. Chem.* **18**: 1440-1449.

Lake sturgeon liver homogenates were examined to determine their oxygen consumption rate, total lipid content, plasma protein binding, and *in vitro* biotransformation rates for their capacity to predict toxicokinetic parameter values. The uptake clearance of trifluralin (TF) was predictable based on the oxygen consumption rate. The *in vitro* TF biotransformation rate was a predictor of the *in vivo* metabolic clearance of TF. Lipid content did not predict the volume of distribution of TF. Lake sturgeon values of uptake and metabolism clearance were predicted using the oxygen consumption and the *in vitro* biotransformation rates. These parameters were used to simulate toxicokinetics of the lipophilic herbicide TF.

Schultz, P.T. 1958. King of fishes. *Wis. Conserv. Bull.* **January**: 26-28.

This popular article described the life history of lake sturgeon in Lakes Winnebago, Butte des Morts, Winneconne and Poygan, Wisconsin. Males were thought to have spawned every year after reaching 14 years of age (average 18-22 years). Females matured at 25 years and spawned every 5 years. The population in Lake Winnebago was estimated at 12,500-12,700, of which 11,300 were estimated to be ≥ 40 inches. A 6% annual addition to the catchable population was estimated. In lakes Butte des Morts and Winneconne, the legal-size population was estimated at 3,366-3,782 with an

8% annual addition to the legal class. Smaller lakes may already have been overharvested. Tagging studies and growth rate analyses have shown the sturgeon populations of Lake Winnebago and the Lake Poygan-Winneconne systems to be different, so they should be managed separately. Lower sturgeon harvest quotas were recommended to sustain the present population.

Schupp, D.H., and Macins, V. 1977. Trends in percid yields from Lake of the Woods, 1888-1973. *J. Fish. Res. Board Can.* **34**: 1784-1791.

Commercial yields of walleye from Lake of the Woods increased with declining yields of lake sturgeon and lake whitefish. This correlation was likely due to the change in fishing methods from impoundment gear (pound nets) to entangling gear (gill nets), as sturgeon and whitefish yields declined. From 1952-1973, the few sturgeon caught were all from Ontario waters of the lake.

Scott, E., Jr., Todd, R., Echevarria, C., Coco, C., and Novak, S. 2004. Tennessee lake sturgeon restoration project. In *Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society.* Madison, Wisconsin. Pagination unknown. [Abstract only].

Lake sturgeon were extirpated from the Tennessee River approximately 50 years earlier due to poor water quality, overexploitation, and habitat alteration. A multi-agency restoration team was organized in 1995 to establish self-sustaining lake sturgeon populations and a managed sport fishery. Since 1998, fertilized eggs from the Wisconsin Department of Natural Resources (WDNR) were hatched at the USFWS Warm Springs National Fish Hatchery and stocked each spring. Since July of 2000, over 21,000 lake sturgeon have been stocked into the French Broad, Holston, and upper Tennessee rivers. Recaptures and fishers indicated that there were healthy sturgeon dispersing throughout the upper Tennessee River system.

Scott, W.B., and Crossman, E.J. 1973. Lake sturgeon, *Acipenser fulvescens* Rafinesque, p. 82-89. In *Freshwater Fishes of Canada*. Fish. Res. Bd. Can. Bull. 184 (Reprinted by Gault House Publications Ltd., Oakville, ON in 1998).

The morphology and biology of the lake sturgeon was reviewed and concisely presented.

Scribner, K. 2000a. Molecular genetic characterization of spatial population structure of remnant lake sturgeon populations in the upper Great Lakes basin, p. 10-11. In C. Lowie (ed.) *Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization.* Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **2000-01**. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 7 April 2006].

Scribner, K. 2000b. Why genetic information is important and how it can be used: general background with relevance to sturgeon conservation management, p. 7-8. In C. Lowie (ed.) *Workshop proceedings - Great Lakes lake sturgeon genetics: status, needs, and standardization.* Holiday Inn - Chicago City Center, Chicago, Illinois, December 8-9, 1999. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resource Office, Administrative Report **2000-01**. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/genworks.htm> [accessed 7 April 2006].

Scribner, K. 2002. Genetic guidelines for lake sturgeon gamete takes in the state of Michigan. Michigan Department of Natural Resources Final Study Report **475**: 5 p.

This document was not available for annotating.

Scribner, K.T., Bott, K., Forsythe, P., and DeHaan, P. 2004. Lake Michigan basin genetics sub-project: 2004 final report. Final Report for the Great Lakes Fishery Trust. Project Number 2001.113. Michigan State University, Department of Natural Resources, East Lansing, MI. 31 p.

This document was not available for annotating.

Scribner, K., Dehaan, P., and Libants, S. 2002. Development of a management plan for lake sturgeon within the Great Lakes basin based on population genetic structure: final report. United States Fish and Wildlife Service, Federal Aid Region 3, Fort Snelling, MN. 16 p.

This document was not available for annotating.

Scribner, K., Hayes, D., DeHaan, P., Baker, E., and Smith, K. 2005. Linking lake sturgeon demographics and genetics. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 22 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 7 April 2006].

Scruton, D.A., McKinley, R.S., Booth, R.K., Peake, S.J., and Goosney, R.F. 1998. Evaluation of swimming capability and potential velocity barrier problems for fish. Part A. Swimming performance of selected warm and cold water fish species relative to fish passage and fishway design. Canadian Electricity Association Project 9236 G 1014, Montréal, Québec. xiv + 62 p. + 2 apps.

Swimming capability was examined for anadromous and landlocked Atlantic salmon, brook trout, brown trout, lake sturgeon and walleye. Lake sturgeon (juveniles and adults) were collected from the Moose River basin and Lake Huron. Experiments were conducted at Guelph University. Sixty-three lake sturgeon were collected with a total length range of 12 to 132 cm. Tests were conducted at 7, 14 and 21 $\pm$ 0.5°C. Endurance was measured at 20, 40, 45 and 50 cm/s for fish less than 15 cm. For sturgeon between 23 and 52 cm, endurance was measured at 30 to 90 cm/s, and for sturgeon larger than 100 cm, at 90, 120, 150 and 180 cm/s. Critical speed was tested at 7 and at 14 $\pm$ 0.5°C for small sturgeon, at 7, 14 and 21 $\pm$ 0.5°C for medium sturgeon, and 14 $\pm$ 0.5°C for large sturgeon. Swimming performance increased with fish size at all speeds and temperatures. Maximum sustained speed increased from approximately 0.10 m/s for small sturgeon, to 0.25 m/s for medium sturgeon and to over 0.80 m/s for large sturgeon at 14°C. Sustained swimming performance increased as temperature went up from 7 to 21°C. Prolonged swimming (< 200 min) also increased with fish length and with temperature up to 21°C. This effect of increased temperature declined as velocity increased and disappeared at high swimming speeds. This information was used to construct a model which demonstrated that large sturgeon can swim longer and at higher speeds than small sturgeon. The applicability of this data to lake sturgeon passage was discussed.

Secor, D.H., Anders, P.J., Van Winkle, W., and Dixon, D.A. 2002. Can we study sturgeons to extinction? What we do and don't know about the conservation of North American sturgeons, p. 3-10. *In* W. Van Winkle, P. J. Anders, D. H. Secor, and D. A. Dixon. (ed.) Biology, management, and protection of North American sturgeon. American Fisheries Society, Symposium 28, Bethesda, Maryland.

This paper summarized what is and is not known about sturgeon populations. Aspects examined included the establishment of year-class strength, critical habitats, demographic and genetic restoration, the effects of dams, the role of hatcheries in sturgeon restoration, sustainable harvest, and whether or not the public actually cares.

Seyler, J. 1997a. Adult lake sturgeon (*Acipenser fulvescens*) habitat use, Groundhog River. Ontario Ministry of Natural Resources, Northeast Science & Technology, NEST Tech. Rep. TR-035: v + 20 p. Available from www.borealscience.on.ca [accessed 7 April 2006].

In 1996 a field study was conducted to determine seasonal habitat use relationships of adult lake sturgeon along the Groundhog River. The study area was occupied almost exclusively by adult lake sturgeon, which used low flow areas in the spring and distributed across the whole study area in the fall (when flows were lowest). Water velocity appeared to be the primary factor affecting habitat use.

Seyler, J. 1997b. Biology of selected riverine fish species in the Moose River Basin. Ontario Ministry of Natural Resources, Northeast Science & Technology, NEST Information Report IR-024: viii + 89 p.

This report offered information on the distribution and ecology of river dwelling fish species in the Moose River basin, including lake sturgeon, walleye, northern pike, smallmouth bass, lake whitefish, goldeye, mooneye, common white sucker, and longnose sucker. Information on life histories, habitat use, diet, and contaminant levels was also given. The tributaries of the Moose River basin were highly fragmented making knowledge of fish and their habitat relationships valuable.

Seyler, J.C. 1997c. Habitat utilization by juvenile lake sturgeon (*Acipenser fulvescens*) in a northeastern Ontario clay belt river. In Third International Symposium on Sturgeon. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Pagination unknown. [Abstract only].

Seyler, J.C. 1997d. Population dynamics and habitat utilization by lake sturgeon (*Acipenser fulvescens*) in a northern clay belt river, p. 527. In 59th Midwest Fish and Wildlife Conference - Managing Natural Resources: Integrating Ecology and Society, Milwaukee, Wisconsin, December 7-10, 1997. [Abstract only].

Seyler, J. 2002. Lake sturgeon assessment: Lake Nipissing, 2001. Anishinabek/Ontario Fisheries Resource Center (A/OFRC) [North Bay, ON] Report 02-04: iv + 12 p.

Adult lake sturgeon were sampled with gillnets set below Sturgeon Falls and the Chapman Chutes on Lake Nipissing. The Chapman Chutes site was sampled from May 22nd to 30th, and the Sturgeon Falls site from May 30th to June 6th. Fork length, total length, weight, and sex (where possible) were determined for each sturgeon. Metal tags were attached to the dorsal fin and a small section of the pectoral fin ray was removed for aging purposes. Sixty-four lake sturgeon were captured. The sex ratio was 7.5 males to 1.0 female for the 34 sturgeon for which sex was determined. Ages ranged from 14 to 40 years, and 18 year classes were represented. Mean ages were 21.2 years for males and 28.2 years for females. The mean weight was 17.2 kg, and the mean total length was 135.6 cm. Signs of recovery that may be evident in future spawning assessments include an increased abundance of spawning lake sturgeon, an increase in the number of year classes represented, the disappearance of gaps in age structure, increased representation of older year classes, continued recruitment of young adults, and a shift towards a more even sex ratio.

Seyler, J. 2003. Lake sturgeon (*Acipenser fulvescens*) spawning assessments: Mississauga River, 1998 - 2002. Anishinabek/Ontario Fisheries Resource Center (A/OFRC) [North Bay, ON] Report 03-06: v + 11 p.

Commercial lake sturgeon harvests from Lake Huron were depicted from 1890 to 2000 in 5-year increments. Lake sturgeon were captured

in gillnets set at two locations below the Mississauga Chutes. Each sturgeon was measured for total length, fork length and weight. Sex was determined when possible, and numbered metal tags were attached to the rear edge of the dorsal fin. A small section of the pectoral fin ray was removed for aging purposes. A total of 363 lake sturgeon were caught between 1999 and 2002. All were captured at the Mississauga Chutes with the exception of 5 that were captured in a pool, approximately 1 km below the Chutes, in 2002. The sex ratio was 1.4 males to 1.0 female for the 136 sturgeon for which sex was determined. A total of 269 sturgeon were tagged, and 282 were aged. Ages ranged from 6 to 60 years, and 37 year classes were represented. Annual mortality was calculated at 12.3% based on year-class frequency data from all four years of study. Mean ages, weights, and lengths for males, females and both combined were presented. Lake sturgeon congregate to spawn at the base of the lower falls on the Mississauga River. The author recommended that similar projects be conducted for 5 to 7 consecutive years during every 20 year period to identify changes in age structure and mortality, and the continued monitoring of lake sturgeon movements through the collection of tag return data.

Seyler, J., Evers, J., McKinley, S., Evans, R.R., Prevost, G., Carson, R., and Phoenix, D. 1996. Mattagami River lake sturgeon entrainment: Little Long Generating Facilities. Ontario Ministry of Natural Resources, Northeast Science & Technology, NEST Technical Report TR-031: Various pagination. Available from www.borealscience.on.ca [accessed 7 April 2006].

In 1995, a multi-disciplinary committee was formed to find solutions to the Adam Creek lake sturgeon entrainment problem. The stranding of lake sturgeon in the Adam Creek diversion after spill periods concerned a variety of governmental agencies and interest groups. The pros and cons of measures designed to minimize or eliminate the problem were discussed. Key recommendations included the need for immediate testing to determine the behavioural responses of lake sturgeon to different kinds of barriers, and for a complete risk assessment to determine the impacts of entrainment on the upstream population.

Sheehan, R. 1989. Mattagami River baseline biological study, 1986-1987. Ontario Hydro Research Division Report No. **89-34-K**: Pagination unknown.

This document was not available for annotating.

Sheehan, R.W. 1992. Adam Creek lake sturgeon monitoring program August 1990 and July 1991. Ontario Hydro Research Division. Report No. **92-165-K**: 59 p.

Eight hundred and twenty-seven lake sturgeon were collected from pools immediately below the Adam Creek control structure in 1990 following a prolonged spill event. One hundred and thirty-two sturgeon had been previously relocated from one of the pools. All viable fish were tagged and released upstream in the Little Long Generating Station (G.S.) headpond. There were low sturgeon numbers north of the control structure. Recapture of tagged fish in Adam Creek prior to the 1990 spill showed successful overwinter survival and accumulation of lake sturgeon in the pools. In 1991, studies indicated low lake sturgeon entrainment during the shorter spill period and successful survival of relocated lake sturgeon in the Little Long G.S. headpond.

Sheehan, R.W., and McKinley, R.S. 1992. Mattagami River lake sturgeon mark-recapture population study 1991. Ontario Hydro Research Division. Report No. **92-164-K**: vi + 107 p.

In 1991, a mark-recapture population study was conducted to estimate the population of lake sturgeon in the Little Long Generating Station headpond on the Mattagami, Groundhog, and Kapuskasing rivers. The population was estimated at 24,772 individuals with 95% confidence limits of 16,359 to 39,401. The age of the fish ranged from 4 to 69 years, with an annual mortality rate of 0.119. The maximum movement recorded was 32.5 km southward. The biomass estimate of 32.08 kg per ha was relatively high for the Moose River basin.

Shively, J.D., and Kmiecik, N. 1989. Lake sturgeon aquaculture project, p. 6-12. *In* Inland Fisheries Enhancement Activities Within the Ceded Territory of Wisconsin During 1988. Great Lakes Indian Fish and Wildlife Commission. Odanah, WI. Admin. Rep. **89-1**.

Results of three fisheries enhancement programs, one of which was the culture of lake

sturgeon, were discussed. The lake sturgeon program was conducted in association with the Bad River and Lac du Flambeau Indian tribes. Four female and two male sturgeons were snared (one was dip-netted) from the Bad River Falls area. A total of 221,192 eggs were collected by caesarean section and milt was collected by stripping. Following fertilization in the field, eggs were incubated at the Lac du Flambeau hatchery at 4-6°C. Hatching commenced on day 12, and a total of 6,000 larvae hatched (7% of eggs incubated). Of these, 3,000 fry (< 1 inch) were stocked into a rearing pond and left to overwinter. The remaining 3,000 were transferred to the Bad River Natural Resources hatchery and reared on brine shrimp, annelids, zooplankton nauplii and Pacific krill. A total of 830 survived to 4-6 inches in length. These fish were micro-tagged and fin-clipped and stocked in the St. Louis River (290 fish) and in the Bad River (540 fish). Construction of a weir at the falls dam to capture more spawners and the use of higher temperatures for incubating fertilized eggs were recommended.

Shouder, M.F. 1975. A progress report on the lake sturgeon in the Black Lake system, Cheboygan and Presque Isle counties. Mich. Dept. Nat. Res. Fish. Div. Tech. Rep. **75-8**: 6 p.

Lake sturgeon in Black Lake were surveyed with gill nets (8 or 10 inch mesh) for four years (1970-73) during May and early June. The efficiency of gill nets can be increased by reefing (take a 14 foot deep net and reef down to 8 feet). Fish were tagged with two dart tags placed at the base of the anterior end of the dorsal fin, and the leading fin bone from the pectoral fin was removed for aging. A total of 136 lake sturgeon were tagged and released. Most fish caught had full stomachs, suggesting they were feeding rather than spawning. Attempts made to collect small sturgeon using boom and stream shockers and a back pack shocker were unsuccessful. Artificial spawning reefs were constructed by using rock riprap on the outside of a river bend and constructing a rock deflector on the inside of the bend to speed water flow into the rock riprap. A histogram of sturgeon year class strengths was constructed; no decline in year class strength was apparent.

Sims, B., Stinson, C., and Surprenant, C. 1999. Life history, status and distribution of lake sturgeon in the Ohio River basin (draft). United States Fish and Wildlife Service, La Crosse Fishery Resources Office, La Crosse, WI. 13 p.

This document was not available for annotating.

Singer, T.D., Mahadevappa, V.G., and Ballantyne, J.S. 1990. Aspects of the energy metabolism of lake sturgeon, *Acipenser fulvescens*, with special emphasis on lipid and ketone body metabolism. Can. J. Fish. Aquat. Sci. 47: 873-881.

Levels of nonesterified fatty acids were measured in the plasma of lake sturgeon as an indicator of fatty acid turnover. Long chain fatty acids, specifically arachidonic, eicosapentaenoic and docosahexaenoic acids, were also measured. The enzymes assayed for included, carnitine palmitoyltransferase, carnitine octanolytransferase, carnitine acetyltransferase and citrate synthetase, 3-hydroxyacyl CoA dehydrogenase, malic enzyme, B-hydroxybutyrate dehydrogenase, succinyl coenzyme-A ketotransferase acetyl-CoA thiolase, hexokinase, phosphofructokinase, lactate dehydrogenase (LDH), glutamate dehydrogenase, alanine aminotransferase, and aspartate aminotransferase. Based on the assays, lipid oxidation occurred in the liver as well as all extrahepatic tissues (brain, red muscle, heart and kidney). Lipid oxidation appeared to be intermediate between elasmobranchs and teleost fishes. The low level of lipid oxidation in sturgeon tissues appeared to be supported by low levels of lipases in adult sturgeon. Oleic acid levels were high in the plasma of sturgeon. The presence of a beta-hydroxybutyrate dehydrogenase activity in the tissues of lake sturgeon was similar to elasmobranchs.

Skaptason, J.B. 1926. The fish resources of Manitoba. Manitoba Industrial Development Board, Winnipeg, MB. 43 p.

A detailed description of the fisheries resources of Manitoba, replete with photographs depicting harvests and contemporary commercial operations, was provided. Lake Winnipeg and its tributary rivers (vicinity of Berens, Pigeon, Bloodvein, and Winnipeg rivers) were considered prime sturgeon fishing areas and Manitoba waters were recognized as the last

important resort for sturgeon on the continent. Lake sturgeon from these waters commanded the highest price of any North American fish. The sturgeon fishing season was from June 15th to October 15th, and 12 inch mesh was the legal size. Winter fishing on Lake Winnipeg took place between 15 November and the end of February. Among the less important lakes, the Sturgeon and Cumberland lakes were traditionally fished for sturgeon in the summer. Beaver and Moose lakes also provided some sturgeon catches. Serious depletion of sturgeon stocks of the Big Saskatchewan River (sturgeon limit increased from 50,000 pounds to 65,000 pounds in 1923) by heavy poundnet fishing was prevented by timely intervention from the Fisheries Administration. The Nelson River (sturgeon limit increased in 1924 from 100,000 to 140,000 pounds) yielded sturgeon for 10-12 years although Playgreen Lake was fished for sturgeon for 30 years. The catch was brought to Selkirk via Lake Winnipeg, and later construction of the Hudson Bay Railways allowed access to other lakes, such as Split Lake. The Bladder Rapids north of Playgreen and Cross lakes were considered a natural barrier for sturgeon. The Churchill River (sturgeon limit: 100,000 pounds) was fished for sturgeon for the first time in 1924-1925, between Duck and Pukatawagan lakes. In the downstream waters of Granville and Indian lakes, the sturgeon were considered larger and more plentiful but not yet commercially exploited. Freight hauling drawbacks prevented earlier and more extensive commercial exploitation. The Hayes River was noted as potentially the "most valuable unexploited sturgeon fishery resource". In 1924, 146,800 pounds of sturgeon with a market value of \$75,400 were taken from Manitoba's northern waters. Additionally, 3,180 pounds of caviar yielded \$3,223. The period of 1920-1924 also saw a steady increase in lake sturgeon production, from 397 Cwt. in 1920 to 2,359 Cwt. in 1924, with a concomitant increase in caviar harvest from 200 pounds in 1920 to 3,980 pounds in 1924. Lake sturgeon were described as being rare in the estuaries but plentiful in the upper reaches of the Nelson and Hayes rivers. Efforts at culturing sturgeon were discussed and one early successful attempt by C.P. Paulson (Superintendent, Gull Harbour hatchery) in 1924 was described. Eggs were hatched yielding 8,000 fry, but ripe females could not be obtained the following year. The author cautioned that, with increasing fishing pressure, attention should be given to proper management of the

province's sturgeon fishery including replenishing stocks with culture efforts.

Sklyarova, T.V., and Raikova, E.V. 1967. Free living stages of the parasite of Sterlet eggs (*Polypodium hydriforme* Ussov, Coelenterata) in the Upper Don. *Parazitologiya* (Leningr.) 1: 200-206.

Free-living polyps of *Polypodium hydriforme* were found in July of 1961 and July of 1962 in the Upper Don River. Morphological and histological characteristics of the polyps were described and their similarity with the polyps cultured in aquaria was shown. The presence of this parasite in plankton samples indicated that they were not purely benthic and may be distributed downstream through drifting.

Skryabina, E.S. 1974. Gel'minty osetrovyykh ryb (*Acipenseridae* Bonaparte, 1831). Izd. Nauka, Moskva. 167 p.

This monograph on the helminthes found in acipenserids discussed each species of helminth separately in the first section, and each species of acipenserid separately in the second. The following parasites were listed under *Acipenser fulvescens*: *Diclybothrium armatum*, *D. hamulatum*, *Acrolichanus auriculatus*, *Allocreadium* sp., *Skrjabinopsolus manteri*, *Diplostomum* sp. metacercariae, *Cucullanus clitelarius*, *Rhabdochona cascadiella*, *Spinitectus* sp., *Metechinorhynchus salmonis*, and *Tanaorhamphus ambiguus*.

Slade, J. W., and Auer, N. A. (ed.) 1997. Status of lake sturgeon in Lake Superior. A report prepared for the Lake Superior Technical Committee by the Lake Sturgeon Subcommittee. Great Lakes Fishery Commission, Ann Arbor, MI. Pagination unknown.

This report reviewed the population structure of lake sturgeon in Lake Superior. The history of the lake sturgeon fishing industry in the area, the species' biology, its population characteristics, juvenile and spawning habitats and movements, and propagation and harvest were also described. Rehabilitation of sturgeon in the area proved challenging because of effects of fishing, physical barriers to migrating fish, impacts of hydroelectric operations, the potential loss of genetic stocks, and the limited amount of knowledge of the life history and abundance of sturgeon. Areas of concern identified included

toxic chemicals, predation by sea lampreys, the commercial sale of sturgeon, and the stocking of exotic piscivores in the lake.

Slifer, G.E. 1969. You can tell. *Wis. Conserv. Bull.* 34: 5.

This short note drew attention to the main differences between lake and shovelnose sturgeon in view of the difficulty that many anglers had in differentiating the two species. The shovelnose sturgeon has four papillose lobes on its lower lip while the lake sturgeon has two. There was an accompanying photograph of the ventral view of the heads of the two species and a diagram of the two sturgeon with some other external distinguishing features labeled.

Smith, C.G. 2003. Historical and present locations of lake sturgeon (*Acipenser fulvescens*) in Saskatchewan. Saskatchewan Environment Fish Wildl. Tech. Rep. 2003-2: v + 32 p.

Over 150 people were interviewed for anecdotal information on lake sturgeon in Saskatchewan. The earliest lake sturgeon observation were at Connell Creek in the 1920s, and the earliest catch was in the City of Prince Albert in the 1940s. The most common fishing gear used in rivers was walleye and pike rigs. Single hooks, jigs, treble hooks, bottom bouncers and spinners were also used. Sinkers of 1 to 6 ounces were used depending on current strength, as hooks need to be near the bottom. Dead minnows were the most common and successful bait used. Other bait included night crawlers, earthworms, leeches, beef heart or fat, any smelly meat, salmon heads, shrimp, crayfish, and a piece of red cloth. A total of 107 sites of known sturgeon occurrences were found in Saskatchewan. Thirty sites were in the South Saskatchewan River, 48 in the North Saskatchewan River, and 33 in the Saskatchewan River. Locations of frequent occurrences are described. Three historical sites were noted in the South Saskatchewan River, 9 in the North Saskatchewan River, and 13 in the Saskatchewan River. Each historical location was briefly described. Spawning and rearing areas, sizes and ages, and abundance were also discussed. A list of eight recommendations was included.

Smith, H.M. 1914. Passing of the sturgeon. Rep. U.S. Comm. Fish Fish. 1913: 66-67.

The decline of the sturgeon due to its destruction as a nuisance fish and later harvest for caviar and meat, was discussed. The catch of Atlantic sturgeon declined from 7,000,000 pounds to less than 1,000,000 in 15 years. There was a similar decline in the Pacific sturgeon from 3,000,000 to a few hundred thousand pounds in a decade. The sturgeon fishery reached its peak of 12-15,000,000 pounds circa 1890, and by 1914 had declined to about 1,000,000 pounds. Attempts at artificial propagation failed. The commercial extinction of sturgeon in the United States was predicted. To prevent this, a 10 year plus ban on the capture and sale of sturgeon was recommended for states with sturgeon, and with consideration of the transplanting of sturgeon.

Smith, K.M., and Baker, E.A. 2005. Characteristics of spawning lake sturgeon in the upper Black River, Michigan. *N. Am. J. Fish. Manag.* **25**: 301-307.

The biological conditions of spawning lake sturgeon in the Upper Black River were assessed and compared to that of other populations. Adult sturgeon were captured in dipnets and measured for total length, fork length, girth, and weight. Gender was determined and all sturgeon were tagged. A total of 115 lake sturgeon were captured in the 2001 spawning period and 104 in 2002. The ratio of males to females was 1.55:1 in 2001, and 2.06:1 in 2002. Total length ranged from 112-187 cm in 2001, and 109-185 cm in 2002. Males were generally smaller than females. Condition factors for females were 4.03 (SE: 1.36) in 2001, and 4.17 (SE: 1.17) in 2002. For males, the condition factors were 3.5 (SE: 1.18) in 2001, and 3.78 (SE: 0.61) in 2002. The Black Lake population was considered similar to other populations despite its confinement to a restricted habitat.

Smith, K.M., and King, D.K. 2005. Movement and habitat use of yearling and juvenile lake sturgeon in Black Lake, Michigan. *Trans. Am. Fish. Soc.* **134**: 1159-1172.

This study examined habitat selection and movements of yearling and juvenile lake sturgeon in Black Lake, Michigan. Sturgeon were surgically implanted with ultrasonic transmitters and movements were monitored. Yearling lake sturgeon were most often associated with sand and organic substrates.

The depth zones most selected were within the 1.5- and 12.2-13.7-m contours. The most selected habitat for yearling lake sturgeon was deep offshore and shallow nearshore, followed by flat bottomed, non-vegetated and vegetated habitats. Juvenile lake sturgeon were most often associated with sand and sand-organic substrate types. Depth zones most selected were within the 13.7- and 6.1-m contours. The most selected habitat for juvenile lake sturgeon was deep offshore, followed by flat bottomed, non-vegetated, shallow nearshore, and vegetated habitats. Chironomidae, mayflies, oligochaetes and Unionidae made up the bulk of the deep offshore benthos community. The results of this study were compared to those of other similar studies.

Smith, O.H., and Van Oosten, J. 1939. Tagging experiments with lake trout, whitefish, and other species of fish from Lake Michigan. *Trans. Am. Fish. Soc.* **69**: 63-84.

Of 2,903 fish tagged and released in Lake Michigan, 388 were recaptured. Approximately 81% of the recaptured fish were taken within a radius of 25 miles from the tagging site (Port Washington, Wisconsin). Lake sturgeon moved extensively within the lake. Data were collected on growth and age for the species recaptured.

Smith, S.H. 1968. Species succession and fishery exploitation in the Great Lakes. *J. Fish. Res. Board Can.* **25**: 667-693.

Fish stocks in the Great Lakes were considered to be in fragile condition, with exploitation favoring different species at different times depending on their body size and the fishing method. Major changes to the fishery were less common before the 1930s than in recent years. Lake sturgeon were intentionally overexploited during the late 1800s because they interfered with fishing of more desirable species. Lake sturgeon stocks were greatly reduced by the turn of the 20th century.

Smith, S.H. 1972. Factors of ecological succession in oligotrophic fish communities of the Laurentian Great Lakes. *J. Fish. Res. Board Can.* **29**: 717-730.

Lake sturgeon were heavily exploited in all of the Great Lakes in early fisheries. They were not considered a valuable catch and frequently damaged nets used for fishing other species.

Consequently, they were fished heavily to remove them from the fishery altogether. The order of preference by fisheries had been coregonines, salmonines, percids, and lake sturgeon, but lake sturgeon were the first to show significant permanent and negative response. The author postulated that other factors were involved in the decline of lake sturgeon because, although they were vulnerable because of their slow growth, late maturity, and ease of capture, there appeared to be no relationship between the order of fishery development and decline. Consequently lake sturgeon were only common in local areas and had not been able to recover to significant levels, even with limitations on fishing. Major reasons for unsuccessful recovery may have been a reduced reproductive capability caused by low population density, alteration of spawning areas, and deteriorating water quality.

Smith, S.H. 1995. Early changes in the fish community of Lake Ontario. Gr. Lakes Fish. Comm. Tech. Rep. 60: 38 p. Available from www.glfc.org/pubs/TechReports/Tr60.pdf [accessed 7 April 2006].

Fisheries on the Great Lakes of southern Ontario prior to 1900 were highly productive. In particular, seine fisheries that were established on the shores of Lake Ontario were intensive and wasteful. Small whitefish, lake herring, and lake sturgeon were destroyed because they were seen as nuisance species. As fish became less abundant near the shore, gillnets and trapnets were used until the sharp decline in the mid-1800s.

Smith, T.I.J., and Dingley, E.K. 1984. Review of biology and culture of Atlantic (*Acipenser oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*). J. World Maricult. Soc. 15: 210-218.

This review dealt mainly with the two species in the title but mention is made of the fact that a paucity of simultaneously ripe males and females, coupled with fungal infection of incubating eggs, were the principal causes of the early failures of lake sturgeon (as well as other sturgeon) culture efforts.

Smith, T.I.J., Lamprecht, S.D., and Hall, J.W. 1990. Evaluation of tagging techniques for shortnose sturgeon and Atlantic sturgeon, p. 134-141. In N.C. Parker, A.E. Giorgi, R.C.

Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans (ed.) Fish-marking techniques: proceedings of the International Symposium and Educational Workshop on Fish-Marking Techniques held at the University of Washington, Seattle, WA, June 27-July 1, 1988. American Fisheries Society Symposium 7, Bethesda, MD.

This study assessed the reliability of tags for use in population estimation and assessment of stock enhancement programs. Marks and tags tested included India ink tattoo, subcutaneous injection of acrylic paint, dart tags with nylon T-anchors, Carlin tags, Archer tags, an internal anchor tag, monel strap tags, and passive integrated transponder (PIT) tags. Three tags appeared suitable for sturgeon. The Carlin tag, attached through the base of the dorsal fin, and the abdominal internal anchor tag were the best external tags. The internal anchor tag was best for shortnose sturgeon held in fresh water to allow healing. Serious lesions and eventual breakdown of the body wall occurred if they were returned to brackish water before healing was completed. Additional testing was required for the PIT tag and tag cost was relatively high.

Smol'yanov, I.I., and Raikova, E.V. 1961. The occurrences of sexually mature *Polypodium hydriforme* Ussov (Coelenterata) on sturgeon juveniles. Dokl. Akad. Nauk SSSR 141: 1271-1274.

Free-living stages of *Polypodium hydriforme* were collected in the course of examining sturgeon larvae from the Saratovsk and Turbensk spawning beds. Some of the polyps had produced a hemispherical formation and all were closely applied to the body of the prelarval fish. These structures corresponded to large mature male gonads, four per polyp situated at the aboral end. Gonads were sealed within an ectodermal operculum containing cnidoblast glutinants, indicating that they functioned as spermatophores. The behavior of the mature polyps was described under aquarium conditions. Polyps adhered strongly to the fish by their tentacles and deposited the gonads in various positions; on the yolk sac, on the muscular portion of the trunk, and on the fins folds and tail ends.

Société de la faune et des parcs du Québec. 2000. Plan de gestion de l'esturgeon jaune du fleuve Saint-Laurent 2000-2002. FAPAQ, Directions de l'aménagement de la faune du Centre-du-Québec, de Lanaudière, de la Montérégie et de Montréal. 21 p.

This document was not available for annotating.

Sopuck, R.D. 1987. A study of the lake sturgeon (*Acipenser fulvescens*) in the Sipiwek Lake area of the Nelson River, Manitoba, 1976-1978. Manit. Dept. Nat. Res. Fish. Br. MS. Rep. 87-2: iv + 59 p.

At writing, the Nelson River supported one of the remaining commercial sturgeon fisheries in North America. Catches had declined since exploitation began in 1907. This study was restricted to the confluence of the Landing and Nelson rivers and encompassed management areas 2 and 3. Exploitation of this resource and changes in the Upper Nelson River population since 1961 were assessed and sturgeon migration was studied. The length-weight relationship was expressed by $\text{LogW} = -11.85 + 3.03 \text{ LogL}$ ($r = 0.95$) for 142 fish collected in 1977 and by $\text{LogW} = -12.93 + 3.26 \text{ LogL}$ ($r = 0.96$) for 142 fish collected in 1978, where W is weight in kg and L is fork length in cm. The Nelson River sturgeon grew isometrically. Mean lengths of fish collected in 1977 (112.9 cm) and in 1978 (108.9 cm) were not significantly different. However, mean weights for 1977 (12.6 kg) and 1978 (10.5 kg) were significantly different. Sturgeon caught ranged in age from 16-70 years. The population size was estimated to be 3,236 by mark recapture (tagging) studies, with an exploitation rate of 0.104. The conditional and instantaneous fishing mortality rates were 17.4 and 18.4 times that of conditional and instantaneous natural mortality rates, respectively. Only 3 of the 47 recaptured sturgeon were collected downstream. The majority (56%) were captured within 30 days of release and 57% were captured within 10 km of the tagging site. Problems associated with sexing fish were discussed. A late spring in 1978 resulted in a delayed spawning migration; ripe males were taken from May 12-23 in 1977 but not until May 31 in 1978. The age structure of sampled fish showed a shift towards younger fish. Lower catch quotas were recommended to manage the Nelson River sturgeon.

Stafford, J. 1904. Trematodes from Canadian fishes. Zool. Anz. 27: 481-495.

Parasites recovered from *Acipenser fulvescens*, obtained from Montréal fish markets, were reported. *Diplobothrium armatum* was reported from the gills, 20 x 1 mm in size. *Acrodactyla* was erected as a new genus and Wedl's *Distomum auriculatum* became *Acrodactyla auriculatum*. The trematodes measured 1.92 x 0.54 mm, the oral sucker measured 0.325 mm and the ventral sucker measured 0.275 mm. Other morphological characters were described. The size and arrangement of the ventral papillae was considered distinctive for *Acrodactyla*. *Deropristis hispidus* was reported from the posterior part of the intestine.

Stanfield, R., Riley, J., Mackey, B., Burdett, R.C., Arthur, M., and Watt, I. 1972. Biological studies of the Onakawana area. Ontario Ministry of Natural Resources. Task Force Onakawana Working Paper # 3: ii + 60 p.

This study examined the environmental impacts of the development of lignite coal deposits at Onakawana, Ontario. Three lake sturgeon were netted in the Onakawana River, and a general habitat description was included. Further studies were recommended to improve understanding of the biology of the area.

Stantec Consulting Services, Inc. 2003. Lake sturgeon spawning studies on the Fox River below the De Pere dam 2002-2003. De Pere Hydroelectric Project. Prepared for International Paper Corporation by Stantec Consulting Services, Inc. 49 p.

This document was not available for annotating.

Stegemann, E.C. 1994. Sturgeon - the king of freshwater fishes. 14th and last in a series. The Conservationist August: 18-23.

This article summarized the life history, habitat and distribution, and population status of Atlantic sturgeon (*Acipenser oxyrinchus*), lake sturgeon (*A. fulvescens*), and shortnose sturgeon (*A. brevirostrum*) in New York. The lake sturgeon was listed as threatened by the American Fisheries Society in all states in which it occurred. Similarities and differences between the three species were summarized.

Stepaniuk, J., and Townsend, R. 2002. It was absolutely delicious... northern Manitoba's prehistoric fish (*Mishe - Nahma*). Townsend Communication Group, Lorette, Manitoba. 78 p.

This document examined the history of lake sturgeon in northern Manitoba. Time periods covered include early history (prior to 1902), 1902-1911, 1916-1934, 1937-1947, 1953-1961, 1970-1991, and 1992 to present. Lake sturgeon exploitation in the Nelson River predated the arrival of European settlers, but the extent of this harvest was unknown. Records of the trade in isinglass dated from 1832. Between 1832 and 1891, an average of 143 kg of isinglass was harvested per year. Holzkamm and McCarthy (1988, see in this bibliography) derived a conversion factor of 1 kg isinglass = 284 kg of dressed sturgeon. Using this conversion factor, the average lake sturgeon harvest between 1832 and 1891 would have been 40,612 kg dressed weight. Harvests were discussed for each time period for various areas in northern Manitoba, and a review of stock status and current management was included. Commercial lake sturgeon harvest from Lake Winnipeg (1832-1928) and the Nelson River (1902-2001) were summarized in Table 1. Data were compiled from Manitoba Department of Natural Resources files.

Stephenson, S.A. 1999. Status of lake sturgeon (*Acipenser fulvescens*) in three Canadian Lake Superior tributaries. Ontario Ministry of Natural Resources, Lake Superior Management Unit Technical Report 99-1: 26 p.

In 1998, three tributaries of Lake Superior were sampled for lake sturgeon. Populations appeared to be the most successful in the Kaministiquia River, as a large number of adults were captured. The absence of sea lamprey scars on these fish suggested that they were a resident population. The population of the 11 km of the river examined was estimated at 140 individuals. Only two sturgeon were caught in each of Nipigon and Black Sturgeon rivers, therefore, population size was not estimated. Substrate types and water velocities were examined to determine habitat preferences, but no clear relationships were found. Management recommendations and suggestions for future research were included.

Stewart, D.B., and Lockhart, W.L. 2005. Fishes & Appendix 3 - Marine, estuarine and anadromous fishes reported from the James Bay, Hudson Bay, and Hudson Strait marine regions, p. 8-1 to 8-11 & A-29 to A-40. In An overview of the Hudson Bay marine ecosystem. Can. Tech. Rep. Fish. Aquat. Sci. 2586.

Lake sturgeon were noted on page A-29 as being a semi-anadromous species that is primarily found in freshwater in the James Bay area. The species may occur in the waters of Hudson Bay, as it has been collected in coastal drainages. Lake sturgeon are described as a benthic omnivore that can tolerate salinities up to 15 ppt (juveniles and adults). They are smoked and eaten by subsistence fishers.

Stewart, K.W., and Watkinson, D.A. 2004. Lake sturgeon; esturgeon jaune - *Acipenser fulvescens*, p. 45-47. In The Freshwater Fishes of Manitoba. University of Manitoba Press, Winnipeg, Manitoba.

A description of lake sturgeon and their Manitoba distribution was provided. Spawning, growth and adult size, feeding, habitat, ecological role, and importance to people were also summarized.

Stokes, K. 1998. Resources of the Moose River basin, Ontario, p. 2-3. In Potential impacts of mineral exploration on aquatic environments within the Moose River basin: a discussion paper. Ontario Ministry of Natural Resources, Environmental Information Partnership (EIP), Moose River Basin, South Porcupine, ON.

An investigation of the impacts of mineral exploration on aquatic ecosystems was conducted on the Moose Basin. Lake sturgeon were one of the main species sought after in the sports fishery. Literature searches on this topic produced minimal results, warranting further investigation. It appeared that either there was an absence of published literature or the perception of industry and governmental agencies was that environmental impacts caused by mineral exploration were of little concern.

Stokes, K., McGovern, S.P., and Fiset, W. 1999. Potential impacts of hydroelectric development on aquatic environments: a selected annotated bibliography with emphasis on the Moose River Basin. Ontario Ministry of

Natural Resources, Boreal Science, Northeast Science & Technology (NEST), and the Environmental Information Partnership, South Porcupine, Ontario. NEST Tech. Rep. TR-039: iii + 164 p. + app. Available from www.borealscience.on.ca [accessed 7 April 2006].

This annotated bibliography was prepared as a reference tool for aquatic resource managers involved in hydroelectric development issues, particularly involving the Moose River basin. The contents described environmental impact assessments, evaluation procedures, and mitigation measures.

Stokes, M., Stoll, J.R., Meyers, L.S., and Ditton, R.B. 2004. Managing lake sturgeon: viewing resources from a human dimensions perspective. In Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

In the spring of 2002, a random stratified survey was conducted at three major sturgeon viewing areas to assess the economic impact of a lake sturgeon viewing population. Results showed that the average viewer was a 49 year old white male Wisconsin resident with a post-high school education, had been viewing for 13 years, and had a moderate income. At the time of the survey there was an estimated 3,176 viewers with an economic impact of \$344,198. Approximately 80% of the viewers supported harvest regulation options that would protect sturgeon and supported restoration and/or management activities.

Stoll, J., Stokes, M., Ditton, R., and Meyers, L. 2004. Economic values associated with lake sturgeon: a Wisconsin study of viewing, spearing, and angling. In Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Sturgeon viewing, spearing, and angling activities of 2002 were examined. An on-site intercept survey and secondary data sources identified participants who were then mailed a 12-page survey. The 3,176 viewers spent an average of \$37.50 per trip (2.89 trips/year), generating a regional impact of \$344,198 per year. This assessment revealed a consumer surplus in relation to sturgeon population

changes that varied from \$31 to \$192 for 10% to 30% with decreases and increases in populations.

Stone, F. 2001. Sturgeon assessment on the St. Louis River. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 2 p.

This document was not available for annotating.

Stone, F. 2005. Lake sturgeon and channel catfish assessment on the St. Louis River. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. 9 p.

This document was not available for annotating.

Stone, L. 1900. The spawning habits of the lake sturgeon (*Acipenser rubicundus*). Trans. Am. Fish. Soc. 29: 118-128.

The time of lake sturgeon spawning was difficult to ascertain as were their spawning beds. Fishers almost never caught a ripe and running female in their nets, and eggs were found in every stage of development except running ripe eggs. The first instance of any sturgeon eggs being taken and hatched was that of the Atlantic sturgeon by Seth Green and A. Marks on the Hudson on 7th June, 1875. In cooperation with commercial fishers, the author examined over a hundred sturgeon during their spawning run in May-June of 1899. Females that were captured and held in pens, in anticipation of maturing eggs, failed to become ripe. The gonads were either in pre- or post-spawning stages and presented a complex mix of various stages of oocyte development. Penning continued until the end of June, and although females very close to spawning were captured, no running females or eggs were obtained. Efforts during the spring of 1900 proved that sturgeon went up the Missisquoi River to spawn on the rapids below the Swanton Dam. The spawning season was short (1 week long), eggs were not laid all at once, sturgeon rushed downstream after spawning, and a ripe female was recognized by a sagging abdomen and spawning eggs that ran freely. The mystery surrounding the rarity of ripe and running females was solved by the fact that such females when caught in the nets expelled most of the eggs and became spent. Lake sturgeon eggs were also successfully hatched for the first time under the auspices of the U.S. Fish Commission. The key to successfully

obtaining eggs was the careful handling and confinement of the fish. A lively discussion followed the presentation. The secretary of the association suggested that sturgeon spawned in alternate years and pointed out that male and female sturgeon did not run together. Mr. Ravenel and Mr. Clark debated the verity of the hypothesis that penning maturing females stops them from further maturation.

Stone, L. 1901. Sturgeon hatching in the Lake Champlain basin. *Trans. Am. Fish. Soc.* **31**: 137-143.

Various techniques to overcome the difficulty of capturing ripe and running females, before they released their spawn in the struggle following their netting, were discussed. Trap nets were avoided by sturgeon and poachers proved detrimental to the field-work. The few sturgeon that were captured still holding ripe eggs proved elusive, either spawning at odd times or struggling so violently during stripping that very few eggs could be obtained. Specific instances were vividly described and ultimately eggs were successfully hatched. A make-shift hatchery constructed on the banks of the Lamoille consisted of 22 jars with water supplied from a brook. Developing embryos proved that 90% of the eggs were fertilized, but two days of frost during development lowered water temperature to 45°F and all the embryos died. The eggs fertilized at the Swanton hatchery hatched in 7 days at a water temperature of 65°F. It was inferred from observations that sturgeon did not spawn until water temperatures reached 60°F. It was also pointed out that sturgeon did not mature their spawn, when confined in pens unless very ripe. Stuffing a handkerchief instantly into the female's vent proved the most effective way of preventing egg loss caused by the struggle that ensued when running females were lifted out of the water. The main difficulty was said to be finding males and females simultaneously and eggs were stated to be easy to fertilize and hatch. A stream of water run with sufficient pressure to keep the eggs in motion was considered important for a high proportion of hatching.

Sunde, L. 1959a. The royal fish. *Fishing, A Bulletin for Commercial Fisherman (Winnipeg)* **1**: 20-23.

This popular article discussed the biology of lake sturgeon in Manitoba waters and recounted the

history of exploitation that led to their general population decline in North America. Commercial sturgeon fishing began in Lake Winnipeg shortly after 1887, and by 1900 the annual production reached 981,500 pounds. By 1910, the annual harvest had declined to 30,200 pounds. Consequently, the fishery was closed. The fishery was reopened and closed a number of times thereafter but each time it failed. Sturgeon from Manitoba waters were slow-growing and slow-maturing. The majority of females were said to spawn for the first time at age 25 and males at age 15-20. A graph showing the relationships between age, fork-length, and round weight was included.

Sunde, L.A. 1959b. The sturgeon fishery in Manitoba with recommendations for management (analysis of Nelson River data: 1953-1956). *Manit. Fish. Br. Dept. Mines Res. MS. Rep.* 29 p.

The introduction dealt with the effects of commercial exploitation on lake sturgeon populations along with short notes on the experimental fishery and biology of the species. The bulk of the report discussed management of the Nelson River sturgeon fishery and reviewed the fishery since it began in 1907. A peak and subsequent sharp fall characterized production curves during each of the intermittent periods of fishing between periods of closure, all this despite the fact that harvest limits were never achieved in any year. The harvest data was interpreted to indicate that sturgeon may not have been over-exploited although annual production showed a downward trend since there was an increase in the proportion of large fish from year to year. However, it was felt that the production of 1953-1956 could not be sustained unless the annual quota was kept at 20,000-25,000 pounds. Objections, biological and economic, were raised against the fishing season (June 10/22 to August 8) on the grounds that late spawning sturgeon were susceptible to capture before they had a chance to spawn and nets were fouled up by trapped slime algae. It was recommended that the open season on sturgeon be changed to the fall, beginning in mid-August/early September, and that the minimum legal size be raised to the equivalent of 20 pounds round weight but the weight criteria be replaced by length (25 inches).

Sunde, L.A. 1960. Sturgeon production in Manitoba. Manitoba Fisheries Branch Inter-Departmental Memo to S. Sigurdson. 6 p.

This memo summarized sturgeon harvests from Lake Winnipeg and the Winnipeg, Nelson, and Churchill rivers. There were data from Lake Winnipeg for the years 1876-1927, 1937-1945, 1953-1954, and 1957-1959. Harvest peaked in 1900 at 981,500 pounds. There were data from Winnipeg River for the years 1910, 1939-1947, and 1957-1959. The greatest harvest was 173,000 pounds in 1910. Data for the Nelson River covered the years 1907-1910, 1917-1918, 1921-1929, 1937-1946, and 1953-1959. A peak harvest of 150,000 pounds occurred in 1917. At least 80% of this harvest occurred in a 100-mile stretch of the river near Sipiweesk Lake. Data for the Churchill River spanned the years 1938-1945, and 1953-1958. A maximum harvest of 15,400 pounds occurred in 1940. Data from 1937-1959 included the number of licenses issued. The effects of the fishery closure on production were discussed.

Sunde, L.A. 1961. Growth and reproduction of the lake sturgeon (*Acipenser fulvescens* Rafinesque) of the Nelson River in Manitoba. M.Sc. Thesis, University of British Columbia, Vancouver, B.C. ix + 93 p.

A total of 791 lake sturgeon were sampled from the Sipiweesk Lake (Nelson River) commercial catch between 1953 and 1956 and in 1959. Preliminary studies on methods of age determination showed that most reliable aging was from pectoral spine sections made ideally within 1/2 inch of the basal articulation, although annuli were closely packed and difficult to read, and sometimes impossible, especially in the case of older fish. Sections between 1 and 2 inches away from the spine articulation were easiest to read but usually lacked one annulus.

Suppes, V.C., and Meyer, F.P. 1975. *Polypodium* sp. (Coelenterata) infection of paddlefish (*Polyodon spatula*) eggs. J. Parasitol. 61: 772-774.

Ripe lake sturgeon eggs from Michigan were reported as having an infection rate of 0.07% (*Polypodium* sp.).

Sutton, T. 2005. Potential for lake sturgeon habitat rehabilitation in Green Bay tributaries of Lake Michigan. Progress report - July 2005.

United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 10 p.

This document was not available for annotating.

Sutton, T.M., and Benson, A.C. 2003. Influence of external transmitter shape and size on tag retention and growth of juvenile lake sturgeon. Trans. Am. Fish. Soc. 132: 1257-1263.

The effects of two shapes and three sizes of dummy transmitters on the tag retention and growth of juvenile lake sturgeon in an eight-week experiment were observed. A greater number of compressed transmitters were shed than cylindrical transmitters, and more large transmitters were lost when compared to small or medium. Fish with medium and large transmitters had lower growth than fish with small transmitters and the control group from week 2 to the end of the study. These results suggested that external transmitters should not exceed 1.25% of the body weight and should be cylindrical for telemetry studies of juvenile lake sturgeon.

Sutton, T.M., Benson, A.C., Elliott, R.F., and Meronek, T.G. 2005. Habitat use and movement patterns of age-0 juvenile lake sturgeon in the lower Peshtigo River, Wisconsin. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 20 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 7 April 2006].

Sutton, T.M., Benson, A.C., Elliott, R.F., Meronek, T.M., and Kornley, G.W. 2004. Characterization of early life-history stages of lake sturgeon in the lower Peshtigo River, Wisconsin, and nearshore waters of Green Bay. Final report to the Great Lakes Fishery Trust. Project Number 2001.109. Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN.

This document was not available for annotating.

Sutton, T.M., Johnson, B.L., Bills, T.D., and Kolar, C.S. 2003. Effects of mortality sources on population viability of lake sturgeon: a stage-structured model approach. Project completion report submitted to the Great Lakes Fishery Commission, Ann Arbor, MI. 37 p.

This document was not available for annotating.

Sutton, T.M., Volkman, E.T., Pangle, K.L., and Rajchel, D.A. 2004. Effects of absorbable suture strand diameter on retention of external radio transmitters by juvenile lake sturgeon. *N. Am. J. Fish. Manag.* **24**: 1404-1408.

The purpose of this study was to examine the effects of absorbable suture strand diameter on the short-term retention of external radio transmitters. Transmitters were cylindrical, 19 mm in length, 5 mm in diameter, weighed 1.4 g out of water, and had a lifespan of 14 days. Four diameters of chromic gut absorbable sutures were used; numbers 3/0 (0.200-0.249 mm), 0 (0.350-0.399 mm), 1 (0.500-0.599 mm), and 2 (0.600-0.699 mm). The 40 lake sturgeon in the study had a mean fork length of 282 mm, and a mean wet weight of 117 g. Lake sturgeon were kept in ten 110-L aquaria (4/aquarium). The number 3/0 suture had a mean retention time of 11.8 days, number 0 suture 17.1 days, number 1 suture 17.7 days, and number 2 suture 21.0 days. Transmitters were dislodged by scraping against the sides and bottoms of tanks. There were no mortalities, open wounds or infections. The use of number 2 or larger absorbable sutures was recommended.

Sutton, T., Zeiber, R., Johnson, B., and Kolar, C. 2004. Effects of sea lamprey-related mortality sources on population viability of lake sturgeon in the Laurentian Great Lakes. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Based on the findings of this study the authors recommended that lampricide application in tributaries containing lake sturgeon should proceed with caution to facilitate long-term rehabilitation and management goals. This was because factors that affected subadult and adult lake sturgeon mortality had a greater long-term impact than factors that affected early life stages. Population abundance, the number of age-1 recruits, and the reproductive potential of lake sturgeon showed percentage decreases

with increasing mortality of age-0 juvenile fish during lampricide applications at 4-year intervals. In addition, when larval sea lamprey mortality incrementally decreased after lampricide application, subadult and adult lake sturgeon mortality resulted from increased sea lamprey parasitism with relative decreases in population abundance, the number of age-1 recruits, and reproductive potential.

Swainson, R. 2001. Fish and fisheries of the Lake Nipigon basin, Nipigon River and Black Sturgeon River system from 1840 to 2001. Ontario's Living Legacy, Lake Nipigon Basin Signature Site, Ontario Ministry of Natural Resources, Nipigon, Ontario. iii + 85 p.

Subsistence use of Lake Nipigon fisheries dates back to 8700 B.C. European use began around 1658. The fisheries were used for subsistence purposes only until the early 1900s. The Native fishery primarily targeted lake sturgeon, which were traded to Toronto fish buyers. Lake sturgeon populations collapsed by 1926 and have never recovered. The commercial lake sturgeon fishery has remained at low levels since the collapse. Quotas, licensing, and restricted commercial areas and seasons were discussed. At writing, there were 10 commercial licenses for Lake Nipigon, and all were issued to First Nation or Metis people. In 2000, 75 kg of lake sturgeon were harvested by the commercial fishery. In 2001, the lake sturgeon quota was 450 kg and rehabilitation efforts or studies had not occurred. Water level management and contaminant monitoring were also discussed. Tributaries of Lake Nipigon used by lake sturgeon included the Namewaminikan, Onaman, Ombabika, Little Jackfish, Gull, and Poshkokagan rivers. Most of what is known of Gull River sturgeon was contained in a study completed by Harkness in 1923 (see this bibliography). Lake sturgeon congregated below the Black Sturgeon Dam on the lower Black Sturgeon River during their spring spawning period. This dam had caused the decline of lake sturgeon populations from Black Bay, Lake Superior. Sturgeon were harvested commercially from Black Sturgeon Lake in 1965 (227 kg) and 1972 (38 kg).

Swanson, G. 1986. An interim report on the fisheries of the lower Nelson River and the impacts of hydroelectric development, 1985 data. Manit. Dept. Nat. Res. Fish. Br. MS. Rep. **86-19**: xx + 228 p.

The sturgeon section of this report dealt with a description of the study area and the net set locations for collection. Twenty-six sturgeon were collected in gill nets, and data analyses were completed. Thirteen fish were radio tagged by sewing the transmitter to the dorsal fin (diagrams showing the location are included). A definite pattern of movement could not be ascertained and there were insufficient data to establish population dynamics. Recommendations were that the lower Nelson River not be completely closed to sport fishing.

Swanson, G.M. 1990. The impacts of hydroelectric development on the fisheries of the lower Nelson River, p. 197-220. *In* C.E. Deslisle and M.A. Bouchard (ed.) *Collection Environnement et Geologie*, Volume 9, *Joules in the water*. A symposium sponsored by The Canadian Society of Environmental Biologists, April 6-7, 1989, Complexe Guy Favreau, Montréal, Québec.

A study on the impacts of the construction of the Conawapa Generating Station (G.S.) on brook trout and lake sturgeon is discussed. Objectives included quantifying the impacts of impoundment on the brook trout population, assessing the status of brook trout and lake sturgeon stocks in an existing impoundment, predicting the impacts of future generating stations, and examining the need for fish passage facilities at the Conawapa G.S. Lake sturgeon were sampled with gillnets in the Long Spruce Reservoir in 1985. In 1987, six lake sturgeon were transferred, radio tagged, and released into the Long Spruce Reservoir. Only one lake sturgeon was caught in 1985, and it may have come from the Kettle Reservoir immediately upstream of the Long Spruce Reservoir. Two of the 6 sturgeon released into the reservoir moved out through the turbines, 3 could not be located, and 1 remained near the Long Spruce G.S. The author concluded that based on these results, the Long Spruce Reservoir is unsuitable for lake sturgeon. Lake sturgeon were also gillnetted and radiotagged in the Pre-Development study area. Nelson River lake sturgeon made extensive movements within the system, particularly between the Jackfish Island area and the estuary. Generally, the sturgeon overwintered in the Jackfish Island area and summered in the estuary. Two of the tagged sturgeon also moved into Angling Lake. The author concluded that lake sturgeon will essentially be eliminated from the Limestone

and Conawapa forebays. A few may remain, but not enough to form self-sustaining populations. The larger Gillam Island Forebay might provide for large numbers of lake sturgeon after impoundment.

Swanson, G., and Kansas, K.R. 1987. A report on the fisheries resources of the lower Nelson River and the impacts of hydro-electric development, 1986 data. Manit. Dept. Nat. Res. Fish. Br. MS. Rep. **87-30**: x + 240 p.

A total of 18 sturgeon were collected from June 19-26, 1987. Sixteen were tagged and released and two were transferred to Long Spruce Reservoir. Catch per unit effort varied from 0.33 to 9.00 (number/24 hr). Twenty-three sturgeon were sampled in Angling Lake and ranged in size from 2.3 to 20.0 kg with a mean age of 36.3. Nine sturgeon were radio tagged and total movement of individual fish ranged from 45 to 275 km. Most movement occurred in August and early September. Sturgeon used the Nelson River during the summer months and overwintering occurred in three distinct areas. The authors concluded that sturgeon may have remained in the Angling River Watershed-Gillam Island Forebay system. Permanent closure of the commercial fishery was recommended, as were further field studies.

Swanson, G.M., Kansas, K.R., and Matkowski, S.M. 1990. A report on the fisheries resources of the lower Nelson River and the impacts of hydroelectric development, 1988 data. Manit. Dept. Nat. Res. Fish. Br. MS. Rep. **90-18**: vii + 260 p.

This report dealt with a radio telemetry study started in 1988 on lake sturgeon movements in the Angling Lake/Angling River system. Ten sturgeon were radio tagged and tracked in 11 flights over a period of almost 7 months. Lengths and ranged from 1,009-1,346 mm and weights from 7 -17.1 kg. Ages were given for four fish and ranged from 37 to 59 years. Only one sturgeon was captured in the south-basin area; the remainder were captured in the narrows. All but one sturgeon moved upstream. After the initial movement, most sturgeon were located in the deeper regions of the lake and remained in that general area. Three fish remained in shallower portions of the lake. The longest migration between tracking flights was 12 km upstream by one sturgeon. Two other radio-tagged sturgeon that entered Angling Lake in

1987 were tracked by 17 flights for 11 months from May 12, 1988 and remained in the lake. One individual showed extensive movements, traversing the entire distance between inflow and outflow basins in 3.5 months of tracking and remained in the outflow basin thereafter. The results supported the hypothesis that Angling Lake was a refuge of sorts for Nelson River sturgeon in terms of an overwintering and year-round habitat. The movements observed within the lake, mainly during late summer and early fall, suggested that the sturgeon were searching for a suitable overwintering location in the lake. Extrapolations of the data must take into account the fact that radio-tracking commenced post-spawning and ended well before potential spawning migrations the following year. It was hypothesized that sturgeon may have used Angling River and Lake as spawning areas. In the second part of the study, gill nets were set in the lower Nelson River from below the Limestone Coffey Dam to the B-axis of the proposed Conawapa Generating Station. Three different habitat types were sampled during spring, summer and fall. Three sturgeon were caught, all from the rapids. Sturgeon made up 0.6% of the species composition in the lower Nelson River but did not figure in the composition of Long Spruce Reservoir (forebay, 1985/86 data). Sturgeon, apparently undergoing the rolling and surface breaking ritual of spawning, were sighted at the Lower Limestone Rapids on June 22, 1988 during high water discharge from the dam. It was believed that dislodging and desiccation of the eggs resulted from water level fluctuations caused by the dam. No sturgeon eggs or fry were found during the sampling of the rapids. Maintenance of a minimum flow of water from the dams was recommended to prevent desiccation and displacement of the eggs. Limited spawning probably occurred below the Long Spruce generating station and at the mouth of the Angling River.

Swanson, G.M., Kansas, K.R., Matkowski, S.M., and Graveline, P. 1991. A report on the fisheries resources of the lower Nelson River and the impacts of hydroelectric development, 1989 data. Manit. Dept. Nat. Res. Fish. Br. MS. Rep. 91-03: ix + 248 p.

This data report was from an ongoing study of sturgeon from the Nelson River and Angling Lake. Fourteen sturgeon were collected and tagged. Some samples were collected for

mitochondrial DNA analyses (not reported on), and parasites were determined (tables in the appendix). Limited daily catch data and recaptures were also included. Recommendations included the monitoring of existing radio tags until expiry, investigating Angling Lake and Angling River for juvenile sturgeon, increasing radio telemetry flights during the spring to follow the spawning migration, and determining the feasibility of improving spawning substrate below hydroelectric dams.

Swanson, G.M., Kansas, K.R., and Remnant, R.A. 1988. A report on the fisheries resources of the lower Nelson River and the impacts of hydroelectric development, 1987 data. Manitoba Department of Natural Resources. Fisheries Branch MS Report No. 88-13: viii + 295 p.

The impact of hydroelectric development on the fish of the lower Nelson River area was assessed. Eighteen lake sturgeon were caught with gill nets in the lower Nelson River between June 19 and 26, 1987. Four panels of gillnets 25 m long and 2.5 m deep with mesh sizes of 7.6, 12.7, 22.9, and 30.5 cm stretch measure were used. Sixteen were tagged and released and 2 were transferred to the Long Spruce Reservoir. Weight ranged from 1.23 kg to 11.1 kg and the mean age was 23.5 years. The highest catch-per-unit-effort (9 sturgeon/24 hrs) occurred on June 19-20. Other species caught included northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), lake whitefish (*Coregonus clupeaformis*), longnose sucker (*Catostomus catostomus*), and burbot (*Lota lota*). An additional 2 lake sturgeon were angled from the mouth of Moondance Creek. Total lengths were 953 and 772 mm, weights were 4.1 and 1.9 kg, and ages were 33 and 31 years. Twenty-three lake sturgeon were sampled in Angling Lake in 1987. Weight ranged from 2.3 to 20.0 kg and the mean age was 36.3 years. Radio telemetry results were also discussed. The longest distance travelled was 275 km (145 km downstream and 130 km upstream) by a sturgeon tagged on June 14, 1986. Lake sturgeon used the lower Nelson River in summer as a migration route and foraging area. Overwintering occurred in three areas. Angling Lake may represent a refugia for all or some of the lower Nelson River's lake sturgeon life history stages, and thus, should be viewed as sensitive fisheries habitat. Population estimates were not possible due to the small sample size.

Recommendations included closing the commercial lake sturgeon fishery and keeping it closed, continuing the radio telemetry study, and completing an inventory of the Angling Lake lake sturgeon population to determine its contribution to the overall lower Nelson River lake sturgeon population.

Symbion Consultants. 1991. Cross Lake Band of Indians domestic sturgeon fishing claim – proposed basis for settlement (final report) – January 4, 1991. Symbion Consultants, Winnipeg, MB. Pagination unknown.

This document was not available for annotating.

Symbion Consultants. 1992. Model response: Cross Lake First Nation Nelson River sturgeon fishery NFA implementation. Prepared for Cross Lake First Nation and Savino & Company by Symbion Consultants, Winnipeg, MB. 24 p.

A history of the lake sturgeon fishery in the Nelson River and surrounding area was summarized from 1907-1977. The effects of hydroelectric development on the Nelson River were briefly described. Three objectives for the management of the Nelson River sturgeon sport fishery were proposed. These were to determine the impact of hydroelectric development on Nelson River lake sturgeon, to maintain or increase sturgeon populations in the area from Warren Landing to the mouth of the Nelson River, and to ensure the maximum amounts of benefits from any improvement/rehabilitation of the Nelson River sturgeon fishery go to the residents of local communities. A series of eleven actions that would aid in reaching these three objectives were outlined.

Szabo, N. 2004. Lake sturgeon in Ontario during the past century; collection and summary of newspaper articles. University of Ottawa, Ottawa, ON. 48 p.

This document provided a compilation and summary of 118 newspaper articles from the late 19th to late 20th centuries on lake sturgeon in Ontario. The majority of the articles were from the Globe & Mail and Toronto Star.

Tebby, C.D. 1974. Fishes of Abraham Lake (Reservoir) and the upper North Saskatchewan River, Alberta. Alberta Lands and Forests, Fish and Wildlife Division. Fisheries Research Report 11: xii + 87 p.

Lake sturgeon were briefly discussed on page 28. They have been observed in the North Saskatchewan River at Rocky Mountain House, but no specimens have been secured. A single large lake sturgeon was also observed at Whirlpool Point in October of 1944.

Thibodeau, S. 1997. Déterminants environnementaux de la dérive larvaire de l'esturgeon jaune (*Acipenser fulvescens* Rafinesque) à la rivière des Prairies, près de Montréal et potentiel d'utilisation du strontium radioactif (⁸⁵Sr) comme marqueur vital à court terme des stades précédant la dévalaison. Comme exigence partielle de la maîtrise en biologie, Université du Québec à Montréal. 129 p.

The spatio-temporal distribution of larval lake sturgeon in Rivière des Prairies was examined by zooplankton net hauls. Four transects were made in 1994, two in 1995 and one in 1996. The 1994 results indicated that larvae hatched on May 21 and were most abundant on June 8. In both 1995 and 1996, lake sturgeon larvae hatched on June 5 and reached a maximum abundance on June 20. A longer spawning period in 1994 was most likely responsible for the extended larval hatching period, while lower water temperatures may have delayed spawning and hatching in 1995/96. Larval hatching occurred mostly at night. The cross sections of river that were sampled in 1994 indicated that the larvae were distributed closer to the Montréal side of the river, while the 1995/96 distribution was more uniform. The location where the females laid their eggs was an important factor in determining the distribution of larvae in the river. Linear water flow and current velocity promoted the minimal displacement of larvae in a cross section of river. In 1994, the CPUE of larvae was greater near the surface of the water at sampling sites located further upstream, while the CPUE was higher near the bottom at sampling sites downstream. The CPUE was higher at mid-depth and at the bottom of the river in 1995/96. The distribution of larvae in the water column was similar between day and night. The CPUE of lake sturgeon larvae decreased when going downstream and the reasons for this were speculative. Further studies should be carried out to identify biotic and abiotic factors responsible for the decrease in relative abundance of larvae once hatched. The data could provide important information for recovery efforts and promote stronger age

classes. Lake sturgeon larvae were estimated to number 9 million, 1.6 million and 1.2 million in 1994, 1995 and 1996, respectively. The constant and elevated water flows in 1994 improved their reproductive success. The relatively poor reproductive success observed in 1995 and 1996 was attributed to water levels that were very low in 1995 and extremely high in 1996. More detailed studies should be undertaken on Rivière des Prairies spawning sites in order to better understand the relationship between reproductive success and larval abundance. The final objective of the study was to determine if radioactive strontium (^{85}Sr) could be used as a marker for juvenile sturgeon. The results demonstrated that submerging a lake sturgeon for 24 hours in a bath with a concentration of approximately $2,500\text{--}3,000\text{ kbq}\cdot\text{L}^{-1}$ produced a detectable level for two months following the exposure. The short term radioactive tagging provided valuable information towards determining the recruitment level of young acipenserids.

Thibodeau, S., D'Amours, J., and Fortin, R. 1998. Impact de l'aménagement d'un nouveau secteur de frayère sur l'utilisation du milieu en période de frai et le succès de reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à la frayère de la rivière des Prairies au printemps de 1998. Report prepared for Hydro-Québec, Université du Québec à Montréal. xv + 83 p. + apps.

Results from the second year of a study to determine the impacts from the construction of a canal and creation of an artificial spawning area for lake sturgeon below the des-Prairies River generating station were presented. Catches from experimental gill netting and back calculations of fertilized eggs indicated two spawning occasions, the first between May 4 and 8, peaking on the 7th, and the second and less important spawn between May 13 and 18th. The timing of the 1998 spawning season differed from 1995-1997 and was characterized as earlier with a bimodal frequency distribution which was probably due to the exceptionally fast rise in water temperature observed in April. In the first half of the spawning season, reproducing lake sturgeon were found in an area near Montréal's shoreline and at the northern tip of the spillway. In the second half of the spawning season, fish were abundant at several sampling stations. The artificial spawning grounds were basically void of any eggs and it

was believed that the decrease in flow to less than $1,000\text{ m}^3/\text{s}$ was unfavorable for lake sturgeon. A total of 997 lake sturgeon were tagged on the new spawning grounds in 1998, of which 578 were male, 87 were female, and 332 were of undetermined sex. The population was estimated at 6,269 and 6,875 using the Schnabel and Seber-Jolly models, respectively. Hatching of larval lake sturgeon occurred between May 18 and 31 with two peak periods on May 21 and 24. Egg to larvae survival was 6 times higher in 1997-98 than in 1995-96 due to either the creation of the new spawning grounds or variation in density of spawning fish and/or eggs.

Thibodeau, S., D'Amours, J., and Fortin, R. 1999. Impact de l'aménagement d'un nouveau secteur de frayère sur l'utilisation du milieu en période de frai et le succès de reproduction de l'esturgeon jaune (*Acipenser fulvescens*) à la frayère de la rivière des Prairies au printemps de 1999. Report prepared for Hydro-Québec by Université du Québec à Montréal, Montréal, Québec. xv + 97 p. + apps.

Results were presented from the third and final year of a study on lake sturgeon use of a spawning ground created at the end of the des-Prairies River generating station in 1996. Experimental gill netting and egg collection indicated that spawning occurred between May 5 and 13, peaking between May 7 and 9. Warm water temperatures in 1999 resulted in earlier spawning than in the spring of 1998. Abundance was highest in the northern areas of the river at the base of the spillway and 400 meters downstream. Similar to observations in 1995 and 1998, low water flows in 1999 restricted the use of the southern portion of the river. In 1999, a total of 729 fish were tagged of which 64 were recaptured, yielding an estimate of 4,163 spawning fish (Schnabel and Seber-Jolly method) which was the lowest value calculated since 1995. Lower flows in the des-Prairies River could be the reason fewer fish used the artificial spawning site. Hatching occurred between May 19th and 29th, and peaked on the 23rd and 25th. Absolute abundance and percent survival of sturgeon larvae from the spawning site in 1999 was 1.98 million and 2.39%, respectively. Results from the previous three years were encouraging and demonstrated that the artificial spawning grounds have had a positive impact on the reproductive success of lake sturgeon in the des- Prairies River.

Third International Symposium on Sturgeon. 1997. Booklet of abstracts. Piacenza, Italy, July 8-11, 1997. Various pagination.

This booklet contained the abstracts of presentations from this conference on a variety of sturgeon species.

Thomas, M.V., and Haas, R.C. 1998. Study Performance Report: Evaluation of lake sturgeon *Acipenser fulvescens* populations in the St. Clair River and Lake St. Clair. Michigan Department of Natural Resources, Project No. **F-53-R-14**: 6 p. Available from <http://www.michigandnr.com/PUBLICATIONS/PDFS/ifr/ifrhome/FederalAid/Greatlakes/F-53-R-14/491-98.pdf> [accessed 7 April 2006].

The objectives of this study were (1) to determine lake sturgeon spawning period, distribution of spawning activity and spawning habitat in the St. Clair River; (2) to determine juvenile life history and habitat requirements in the St. Clair River and Lake St. Clair; and (3) to document lake sturgeon population parameters. A total of 187 lake sturgeon were captured in 1997. Total length ranged from 244 mm to 1,762 mm. Ages ranged from 1 to 42 years. One hundred and eighty-two of these lake sturgeon were tagged. A spawning site was identified in the North Channel of the St. Clair River. Water depths at this site ranged from 9-12 m, the flow rate was 1 m/sec, and the substrate consisted of coal cinders ranging in size from <25 mm to >200 mm in diameter. A water temperature of 13.2°C was found at this time of peak spawning activity. There was one tag recovery in 1997 from southern Lake Huron. Tracking results were discussed.

Thomas, M.V., and Haas, R.C. 1999. Capture of lake sturgeon with setlines in the St. Clair River, Michigan. *N. Am. J. Fish. Manag.* **19**: 610-612.

Setlines were used to capture sturgeon in the St. Clair River because of the strong current, steep bottom contours, and water depths greater than 18 meters. This method was relatively successful, with most fish being hooked in the mouth and experiencing little visible damage or stress. However, about 20% of the fish were hooked outside the mouth and in some cases suffered serious bleeding and tissue damage. The highest incidence of snagging appeared to be associated with spawning activity and

behavioral changes. Lake sturgeon caught in the setlines ranged from 0.8 kg to 45.5 kg.

Thomas, M.V., and Haas, R.C. 2000. Study performance report: evaluation of lake sturgeon *Acipenser fulvescens* populations in the St. Clair River and Lake St. Clair. Michigan Department of Natural Resources, Project No. **F-81-R-1**: 7 p. Available from http://www.fws.gov/midwest/sturgeon/mtclem_fedaidd00.htm [accessed 7 April 2006].

In 1999, 172 lake sturgeon were captured in Lake St. Clair and the St. Clair River. Total length ranged from 351 mm to 1,816 mm, and ages ranged from 1 to 62 years. All lake sturgeon were tagged. In 2000, 212 lake sturgeon were captured. Attempts to map a spawning site in the North Channel of the St. Clair River were unsuccessful, as were efforts to determine habitat requirements of juveniles. At writing, 24 tagged lake sturgeon had been recaptured. The majority of the recaptures occurred in the North Channel of the St. Clair River and in southern Lake Huron. Many adults found in the North Channel during the spawning period move into Lake St. Clair and spent the summer and fall in the deeper areas of the US waters of the lake. Some adults stay in the St. Clair River year round.

Thomas, M., and Haas, R. 2001a. Status of the fisheries in Michigan waters of Lake Erie and Lake St. Clair 2000. Prepared for the GLFC Lake Erie Committee Meeting, Niagara Falls, New York, March 28, 2001. Michigan Department of Natural Resources, Fisheries Division. 19 p. Available from http://www.michigan.gov/documents/Mt_Clements_status2000_50845_7.pdf [accessed 7 April 2006].

This report summarized: the fishery forecast for 2001, sport fisheries, the commercial fishery, netting surveys, fish tagging studies, water levels, and sport fishing regulations. A total of 233 lake sturgeon were collected on the St. Clair River and Lake St. Clair in 2000. Total length ranged from 29-74 inches, with an average of 50.4 inches. Two hundred and twenty-five lake sturgeon were aged, revealing 40 year classes and an age range from 6 to 74 years. Two hundred and twenty-four sturgeon were tagged and released, bringing the total to 904 since 1996. Lake sturgeon recoveries were discussed. The harvest of lake sturgeon in Michigan was

prohibited except from the St. Clair River and Lake St. Clair. Regulations included a minimum length of 1,067 mm and a maximum length of 1,270 mm, a season bag limit of 1 fish, an open season from July 16 to September 30, and mandatory registration of harvested sturgeon. There were no lake sturgeon registered in 1999 or 2000.

Thomas, M.V., and Haas, R.C. 2001b. 2000 St. Clair lake sturgeon study performance report. Michigan Department of Natural Resources, Mt. Clemens Fisheries Research Station, Harrison Township, MI. 5 p. Available from http://www.fws.gov/midwest/sturgeon/mtclemens_02update.htm [accessed 7 April 2006].

The three main objectives of this study were (1) to determine the spawning period, distribution of spawning activity and spawning habitat of lake sturgeon in the St. Clair River; (2) to determine juvenile life history and habitat requirements; and (3) to document lake sturgeon population parameters for Lake St. Clair and the St. Clair River. A total of 232 lake sturgeon were captured in 2000. Total length ranged from 744 mm to 1,887 mm, and ages from 6 to 74 years. All lake sturgeon were tagged and released. Attempts to identify habitat requirements of juveniles were unsuccessful due to the low numbers of young lake sturgeon collected. As of 2000, 29 tagged lake sturgeon had been recaptured. Most of these were from the North Channel of the St. Clair River and southern Lake Huron. Preliminary analysis of gut contents revealed zebra mussels, snails, mayfly nymphs and chironomid larvae.

Thomas, M.V., and Haas, R.C. 2002. Abundance, age structure, and spatial distribution of lake sturgeon, *Acipenser fulvescens*, in the St. Clair System. *J. Appl. Ichthyol.* **18**: 495-501.

A study was initiated in 1996 to assess lake sturgeon abundance, age, and spatial distribution in the St. Clair River and Lake St. Clair. Of the 900 lake sturgeon tagged, there were few recaptures, but movement into southern Lake Huron has subsequently been documented. Mark-recapture analysis gave a population estimate of 45,506 lake sturgeon for the St. Clair system, and was consistent with estimates derived from sidescan sonar observations. Pectoral fin ray sections indicated consistent recruitment during the 1970s and

1980s, but low recruitment before 1973 and after 1995. Trawling and sidescan sonar analysis identified an area of consistently high lake sturgeon density in the lake near the St. Clair delta. By studying this area near the delta, researchers may be able to provide more insight into protection and habitat restoration efforts in other Great Lake connecting waters.

Thomas, M., and Haas, R. 2004a. Abundance, age structure, and spatial distribution of lake sturgeon *Acipenser fulvescens* in the St. Clair system. Michigan Department of Natural Resources Fisheries Research Report **2076**: 25 p.

This report adds to the information presented in the previous citation (Thomas and Haas, 2002). Spawning locations, abundance, age structure, and spatial distribution of lake sturgeon in the St. Clair River and Lake St. Clair were examined. The only confirmed spawning site identified was in the North Channel of the St. Clair River near Algonac, MI. Water depth at the site ranged from 9-12 m, flow rate was 1 m/s and the substrate consisted of coal cinders. Between May 1996 and October 2002, 1,238 lake sturgeon were captured of which 1,201 were tagged and released. Ages for 1,106 sampled sturgeon ranged from 1-74 years and represented 55 year classes. Reported tag recoveries through 2002 totalled 56, including 7 that were recaptured twice. Individual histories for fish with multiple recaptures were presented. A 255-ha area of Lake St. Clair was sampled with sidescan sonar and the results were analysed in ArcView®. This gave an estimated population size of 29,262 lake sturgeon in 1999 and 5,038 in 2000. Potential reasons for this large difference were discussed. The report concluded with a list of management implications and future research needs.

Thomas, M., and Haas, R. 2004b. Status of the fisheries in Michigan waters of Lake Erie and Lake St. Clair 2003. Prepared for the GLFC Lake Erie Committee Meeting, Green Island, New York, March 31, 2004. Michigan Department of Natural Resources, Fisheries Division, Lake St. Clair Fisheries Research Station, Harrison Township, MI. 22 p. Available from http://www.michigan.gov/documents/Mt-ClemensStatus2003_86944_7.pdf [accessed 7 April 2006].

Thirty-eight lake sturgeon were collected in

netting surveys on Lake St. Clair in 2003. Total length ranged from 36 to 64 inches and averaged 52.2 inches. Thirty-three lake sturgeon were aged revealing a range of 9-45 years. Thirty-five lake sturgeon were tagged and released, bringing the total to 1,236 since 1996. Recaptures were discussed. Since 1999, 13 harvested lake sturgeon have been registered. All were reportedly caught in the North Channel of the St. Clair River.

Thomas, M.V., Haas, R.C., Caswell, N.C., Boase, J.C., Mohr, L., Koproski, S., Hill, T.D., and Manny, B.A. 2004. Status and management of lake sturgeon in the Huron/Erie corridor. In Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

There was limited information available about lake sturgeon stocks in the Great Lakes, particularly in the 100-mile channel that connects Lakes Huron and Erie. Different rules governing anglers in Michigan and Ontario. As a result, fishery managers requested an examination of lake sturgeon in this corridor. Scientific information relating to lake sturgeon management in this corridor was reviewed.

Thorton, S. 2003. Upper Columbia White Sturgeon Recovery Initiative [Revelstoke, BC]. Summer 2003: 4 p. [Newsletter].

White sturgeon distribution in the Upper Columbia basin was detailed, an update was provided on conservation aquaculture, and the white sturgeon recovery plan was discussed.

Threader, R.W. 1981. Age, growth & proposed management of the lake sturgeon (*Acipenser fulvescens*) in the Hudson Bay Lowland. Ontario Ministry of Natural Resources, Moosonee District. MS. Rep. 106 p.

The lake sturgeon population of the lower Moose River system in the Hudson Bay lowland was investigated to determine population age structure and growth patterns, evaluate tissue mercury levels, and assess the effects of current fishing methods. The population size was estimated at 7,088 (range: 5,774-8,919). A Walford plot showed that there were no deleterious effects of the tagging operation on growth of fish. Tagged fish were randomly distributed throughout the population and tag

loss was believed to be minimal. Evidence obtained in the study indicated a localized population. The relationships between total length (TL, cm), fork length (FL, cm) and dressed length (DL, cm) were given by the equations; $TL = 2.94 DL^{0.882}$, $n = 70$, $r^2 = 0.779$, and $FL = 2.41 DL^{0.902}$, $n = 72$, $r^2 = 0.958$. The length-weight relationship of a representative sample of 375 sturgeon (males & females) was $W = 0.002665 FL^{3.22623}$, where W is weight in grams and FL in fork length in cm (this figure appears to be characteristic of lake sturgeon when compared to other studies). Age-length (FL) and age-weight (W) relationships were expressed by the equations: $\log FL = 1.738 + 0.00973 (\text{Age, males})$, $\log FL = 1.653 + 0.0144 (\text{age, females})$ and, $\log W = 3.003 + 0.0324 (\text{age, males})$, $\log W = 2.722 + 0.0475 (\text{age, females})$. These data indicated that growth could be treated independently of sex. The von Bertalanffy growth curve was expressed by the equation $L_t = 212.176 (1 - e^{-0.0193(t + 6.852)})$, for the age groups 2-28 years. The sex ratio was 1:1. The increase of fish length was rapid (3 cm/year) for the first 7 years but weight gain (100 g/year) was slow. Between 11 and 28 years of age fish gained 388 g/year with a length increase of 2.41cm/year. Between 16 and 23 years of age, instantaneous weight gain was highest (579 g/year) with an increase in FL of 3 cm/year. Beyond 28 years of age, growth decreased (147 g/year, 1.7 cm/year). Lake sturgeon from the lower Moose River were smaller for a particular age class than those found elsewhere. Males began gonadal maturation at 14 years and females at 18 years. Fish became vulnerable to fishing pressure at 7 years. It was suggested in the alternate management plan that smaller sized fish be taken commercially to spare the larger spawners and that 376 kg of fish be taken annually from the recommended range of harvestable fish. A gill-net stretched mesh size of 7 inches would be most effective in capturing the recommended size range (40-90 cm, median of 2.5 kg). Light consumption was advised for fish >90cm and no consumption for fish above 115 cm due to mercury levels of 0.50 ppm in these large fish. The tail walking behavior (breaking water surface) was attributed to air gulping and utilization by these fish, which have a physotomous swimbladder.

Threader, R.W. 1996. Habitat suitability index for lake sturgeon, *Acipenser fulvescens*, p. 73-74. In S. Doroshov, F. Binkowski, T. Thuemler, and D. MacKinlay (ed.) Culture and management of sturgeon and paddlefish symposium. International Congress on the Biology of Fishes. San Francisco State University, July 14-18, 1996.

Ontario Hydro was studying lake sturgeon to develop a Habitat Suitability Index (HSI) model to aid in the protection and conservation of this species, particularly on rivers with hydroelectric dams and associated operations. The model would ideally be applicable to large, slow-flowing rivers within the species' native range. Variables in the model included factors that were considered to be limiting the distribution, abundance, and/or survival of the lake sturgeon within its native range. The two model components were food and reproduction. The four habitat variables selected for food were foraging substrate type for adults, foraging substrate for juveniles, water depth, and water velocity. Variables used for reproduction were temperature, velocity, substrate type, and water depth. The HSI values ranged from 0 to 1, with 0 being unsuitable and 1 being optimal.

Threader, R.W., and Brousseau, C.S. 1986. Biology and management of the lake sturgeon in the Moose River, Ontario. N. Am. J. Fish. Manag. 6: 383-390.

A three year study was initiated in 1980 on the Moose River to determine growth-rates and age at sexual maturity of lake sturgeon, estimate population size, and examine mercury contamination in tissue. The 549 sturgeon sampled in 1980 and 1981 ranged from 2-38 years of age. The length-weight relationship of a sample of 375 sturgeon of all sexes and maturity stages was $W = 0.002665FL^{3.22623}$, where W is weight (g) and FL is fork length (cm), and showed allometric growth. The age-length relationship was as follows; for males $\log_{10}FL = 1.738 + 0.00973(\text{age})$, $r = 0.72$ and for females $\log_{10}FL = 1.653 + 0.0144(\text{age})$, $r = 0.88$, where FL is fork length (cm) and age is in years. Growth of the Moose River population closely approximated northern populations such as that of Lake Nipigon, but was considerably less than southern populations of Wisconsin and Lake Nipissing. The population was estimated at 7,088 and the sex ratio was 1:1. The age at maturity for females was calculated to be 20

years. Tissue mercury levels increased with increasing length of fish and exceeded the allowable 0.5 ppm limit in fish over 102 cm. It was predicted from the Beverton-Holt yield model that increases in fishing pressure would result in over-exploitation. Replacement of the minimum limit of 63 cm for harvestable fish with a maximum limit of 100 cm was recommended. An annual yield of 40 kg could be taken from this recommended range of harvestable fish, resulting in an increase in the exploitation rate for this size range but an overall decrease in exploitation rate from the current 2.5% to 1.8%. This would protect existing spawners and, over time, increase the number of spawners in the population thereby increasing the number of harvestable fish.

Threader, R.W., and Brousseau, C.S. 1987. Biology and management of the lake sturgeon in the Moose River, Ontario, p. 47. In C. H. Olver (ed.) Proceedings of a Workshop on the Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. 23. [Abstract only].

The abstract of this paper was reprinted with permission of the North American Journal of Fisheries Management in which it originally appeared. Please see the above reference for a full summary.

Threader, R.W., Pope, R.J., and Schaap, P.R.H. 1998. Development of a Habitat Suitability Index Model for lake sturgeon (*Acipenser fulvescens*). Report prepared for Ontario Hydro, Northern Development Department by Tarandus Associates Limited, Brampton, ON. Report No. H-07015.01--0012: v + 47 p. + 3 apps.

The purpose of developing a Habitat Suitability Index model for lake sturgeon was to predict the effects of future construction of, modifications to, or operation of hydroelectric generating facilities in Ontario. Age, growth, food, reproduction and specific habitat requirements were discussed. The model was designed for large, low-gradient rivers of north-central Ontario but is applicable throughout the lake sturgeon's native range. Spawning, incubation and summer foraging habitats for riverine lake sturgeon populations are evaluated. Some information on summer foraging of lacustrine populations was also integrated. Two model components representing two life requisites of lake sturgeon were included. These were food and reproduction. For

the food component, four habitat variables were selected. These included adult foraging substrate types, juvenile foraging substrate types, water depth and velocity. The four indicators of habitat suitability chosen for the reproduction component were water temperature, water velocity, substrate type and water depth. Suitability Index graphs were constructed for the eight previously mentioned variables by converting habitat information from published documents and personal communications into habitat suitability graphs ranging from 0 (unsuitable habitat) to 1 (optimum habitat). Rationale, assumptions and information sources for each variable were discussed, and the computer model and output were included in the appendices.

Thuemler, T.F. 1985. The lake sturgeon, *Acipenser fulvescens*, in the Menominee River, Wisconsin-Michigan, p. 73-78. In Binkowski, F. P. and S. I. Doroshov (ed.) North American Sturgeons: biology and aquaculture potential. Dr. W. Junk Publishers, Dordrecht.

A survey of lake sturgeon was carried out on the Menominee River, particularly on the 42 km middle section between White Rapids Dam and Grand Rapids Dam. Fish were sampled by electro-shocking. Estimated numbers were 2,543 for sturgeon between 25-107 cm and 206 for sturgeon longer than 107 m. The data and length frequencies for sturgeon caught compared well with previous studies which were discussed in some detail. Creel data from 1969 and 1970 estimated sturgeon harvests of 59 and 48 fish, respectively. Some aspects of management were also discussed, and the desired exploitation rate was 5%.

Thuemler, T.F. 1988. Movements of young lake sturgeons stocked in the Menominee River, Wisconsin, p. 104-109. In R.D. Hoyt (ed.) 11th annual larval fish conference, June 1-3, 1987, Houghton, MI. American Fisheries Society Symposium 5, Bethesda, MD.

Radio telemetry with surgically implanted radio transmitters was used to monitor the movements of 24 hatchery reared yearling sturgeon of the introduced Lake Winnebago stock and 10 young sturgeon of the native Menominee River stock. A period of one year separated the two studies. Yearlings from the Lake Winnebago stock typically moved quickly downstream. The fastest recorded downstream travel was 39 km/day and

the fastest upstream was 3.2 km/day. The native Menominee River stock dispersed much slower after their release. Their fastest downstream and upstream movements were 14.5 km/day and 5 km/day, respectively. Genetic differences between the Lake Winnebago and Menominee River stocks of lake sturgeon may explain their different behaviour patterns.

Thuemler, T.F. 1997. Lake sturgeon management in the Menominee River, a Wisconsin-Michigan boundary water. Environ. Biol. Fishes 48: 311-317.

This study examined the impacts of new angling regulations on the overexploited lake sturgeon. River stocks were compared before and after the implementation of the new regulations using records of legal harvests from each river section. Exploitation estimates indicated that overfishing was still occurring in two of the three river sections. Further management and protection regulations that would enable the fishery to continue were recommended.

Tidd, W.M. 1931. A list of parasitic copepods and their fish hosts from Lake Erie. Ohio J. Sci. 31: 453-454.

Argulus stizostethi was reported from the lake sturgeon in Lake Erie for the first time.

Tody, W.H. 1974. Whitefish, sturgeon, and the early Michigan commercial fishery, p. 45-60. In Mich. Fish. Michigan-DNR Fish Div. Manage. Cent. Rep. 1873-1973. Mich. Dept. Nat. Res. MS Rep. 6.

This historical account of the whitefish and lake sturgeon fisheries of the Great Lakes, described the bountiful catches of both species in the early days of the fishing industry. The unchecked commercial exploitation of lake sturgeon began after its value was discovered by an entrepreneur in Sandusky, Ohio, who started smoking sturgeon in 1860. However, lake sturgeon had already been destroyed in great undocumented numbers as a trash fish since 1830, when commercial fishing first began on the Great Lakes. The actual population size in the Great Lakes will never be known for certain. Prior to 1860, sturgeon could be obtained free from the fishing docks. The use roe for caviar was unknown in the early days and the flesh was fit only for "servants and slaves". Biennial reports of the State Fish Commission were

extensively quoted to describe the rise and fall of the sturgeon fishing industry.

Toth, G.P., Ciereszko, A., Christ, S.A., and Dabrowski, K. 1997. Objective analysis of sperm motility in the lake sturgeon, *Acipenser fulvescens*: activation and inhibition conditions. *Aquaculture* **154**: 337-348.

The duration of lake sturgeon sperm motility was measured using computer-assisted motion analysis at 200 frames/second. The proportion of activated motile sperm and their velocities did not change after 5 minutes in Trisglycine buffer, pH 9.0, with 10 mM Na⁺ and were observed to last for 30 minutes. The proportion of motile cells was reduced by 50% with the addition of 0.5 mM K⁺. Elemental analysis of seminal plasma showed the following concentrations P (3.02 mM); K (5.78 mM); Ca (0.16 mM); Mg (0.2 mM); Na (25.0 mM); Zn (0.76 mM); and Cl (5.4 mM).

Tough, F. 1996a. 'The fish and waters should be ours': The demise of native fisheries - regulation and capitalization, p. 234-248. In 'As their natural resources fail': Native peoples and the economic history of northern Manitoba, 1870-1930. UBC Press, Vancouver, BC.

This book chapter examined the effect of the development of the commercial fishing industry on the Native fishers and economy of northern Manitoba. After 1890, commercial harvests increased and the industry expanded north. Commercial sturgeon fishing spread and the fishery eventually collapsed. Commercial sturgeon fishing began in the 1880s at Grand Marais and Pigeon River, and soon spread to the lower Saskatchewan and Nelson rivers. Harvest statistics were presented for Lake Winnipeg from 1886 to 1910, and overfishing was cited as the cause for the collapse of the fishery. In 1897, the value of sturgeon and sturgeon products had doubled and in some cases tripled, while the value of whitefish decreased. By 1900, the Poplar River, Norway House and Cross Lake bands began to take part in the commercial fishery. The government preferred to give licenses to locals; of 180 licenses issued for the Nelson River in 1903, 176 went to Indian and Metis fishers. By 1904, the fishery had expanded past Cedar Lake to Cumberland Lake. In the 1920s, the fishery further expanded up the Churchill, Fox and Hayes rivers. The effects of the fishery collapse

on the Native economy were discussed.

Tough, F. 1996b. 'Nothing to make up for the great loss of winter food': Resource conflicts over common-property fisheries, p. 174-186. In 'As their natural resources fail': Native peoples and the economic history of northern Manitoba, 1870-1930. UBC Press, Vancouver, BC.

This chapter examined Native fisheries in northern Manitoba before and after commercialization. Lake whitefish and lake sturgeon were the two most important species. Gear included spears, hooks, hoop nets, gill nets, and weirs. Lake sturgeon provided food, oil, glue from their bladders, and skins that were made into jars. Sturgeon could also be kept alive in holding ponds to serve as a source of fresh food. Lake sturgeon were fished in the early summer, and trading post employees often purchased large quantities in late winter. The commercial fishery resulted in declines of lake whitefish and sturgeon. This meant less food for subsistence fishers. Locals voiced their concerns, and in 1890 an investigation of the fishing conditions on Lake Winnipeg was carried out by Samuel Wilmot. Wilmot agreed with giving Natives local fishing grounds, but this suggestion did not become policy. Natives also wanted more capital in order to compete with large companies, but this was not provided. Some of Wilmot's suggestions did become policy, such as a commercial and domestic licensing system, and some restrictions on where companies could operate.

Tower, W.S. 1908. The passing of the sturgeon: a case of the unparalleled extermination of a species. *Popular Science Monthly* **73**: 361-371.

This paper reviewed the early experiences of human contact with sturgeon on the North American continent. Sources of reference dating back to 1626 described a sturgeon fishery in Virginia which was later abandoned for reasons unknown. This was the first recorded attempt at an organized sturgeon fishery on this continent. The abundance of sturgeon was evident from records as antiquated as William Penn's 1683 letter to the Free Society of Traders identifying sturgeon as the most abundant fish of his state. In view of the fact that references were made to The Bay and the Delaware River, they may have been referring to anadromous Atlantic sturgeon. The distinction between the different species could only be tentatively made from early

statistics showing the distribution of the catch (east coast, west coast and Great Lakes). Historians told of sturgeon leaping into the canoes and boats of the Indians and white settlers. The strong prejudice against sturgeon flesh prevented its emergence as a major industry until after 1850. The history of the early fisheries was reviewed, with the Hudson, Delaware, and James rivers as important sturgeon fishing areas. In 1880, sturgeon from lakes Erie and Michigan (undoubtedly lake sturgeon) constituted 3/5ths of the total US catch. Catch statistics tabulated for the Great lakes region for 1880, 1890, 1897 and 1904 were also probably for lake sturgeon. Statistics for inland sturgeon fisheries were collected for the first time in 1895 and totaled 2,250,000 pounds. Two-thirds of this came from the Minnesota region of the Lake of the Woods. Large catches were also reported from Washington and Oregon. The first signs of impending collapse were already evident in the returns from the Great Lakes which, in 1897, decreased to one-fourth of the 1880 yield. The decline continued and in 1904 the Great Lakes region produced 10% of what it did 20 years earlier. The situation was best described by Lake St. Clair which produced 1,000,000 pounds in 1880, but not more than 10,000 pounds at the time of writing, while that of lakes Michigan and Erie had fallen to one-sixtieth of the 1880 yield. This collapse of the lake sturgeon fishery was considered a result of poor fishing methods; small mesh size gill nets, grappling hooks dragged over spawning grounds and the pursuit of fish during the spawning season. Georgia was the first state to ban all sturgeon fishing for 5 years in 1901, and Minnesota was one of the first states to establish closed seasons for sturgeon. The author concluded by stating that it was without parallel that a fish that was most abundant all over the continent was virtually fished to near extinction in less than thirty years.

TRAFFIC North America. 2003. Caviar and conservation: TRAFFIC examines management and trade of North American sturgeon and paddlefish. TRAFFIC Report 2: 1-4.

The TRAFFIC report entitled "Caviar and Conservation: Status, Management, and Trade of North American Sturgeon and Paddlefish" was summarized (2003, see in this bibliography).

Trautman, M.B. 1954. 152-year-old lake sturgeon caught in Ontario. *Comm. Fish. Rev.* **16**: 28.

This short note reported that a lake sturgeon, 81 inches long and weighing 215 pounds, was caught in July.

Travnichek, V.H. 2004. Sturgeon restoration and management efforts in Missouri: two decades of experience in the show-me state. In *Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society*. Madison, Wisconsin. Pagination unknown. [Abstract only].

The Missouri Department of Conservation managed a restoration program for lake and pallid sturgeon. Approximately 200,000 lake sturgeon had been stocked in the Missouri and Mississippi rivers during the previous 20 years. A monitoring program had been initiated on both rivers to track population trends of shovelnose sturgeon and the success of the stocking program of lake and pallid sturgeon. Habitat restoration efforts were ongoing on both rivers. Results of these efforts were summarized.

United States Department of the Interior. 2002. Comments, recommendations, Section 10(j) terms and conditions, and Section 18 prescription on the application for major license by Ecel Energy for the Holcombe (FERC no. 1983-017), Wisconsin (FERC no. 2567-009), and Dells (FERC no. 2670-014) hydroelectric projects. United States Department of the Interior. 20 p.

This document was not available for annotating.

United States Fish and Wildlife Service. 1994. Second summary of sturgeon and paddlefish researchers and managers. Panama City Field Office, Panama City, Florida. Pagination unknown.

This document included brief notes on completed studies of sturgeon and paddlefish, and a directory of researchers who were active in this field of study.

United States Fish and Wildlife Service. 2001. Lake sturgeon, *Acipenser fulvescens*. United States Fish and Wildlife Service, La Crosse Fishery Resources Office, La Crosse, WI. 2 p. [Brochure]. Available from http://www.fws.gov/midwest/LaCrosseFisheries/reports/Lake_Sturgeon_Brochure.pdf [accessed 10 April 2006].

This brochure described the lake sturgeon and discussed its biology, historic and present range, reasons for decline, artificial propagation, human uses, and rehabilitation efforts.

United States Fish and Wildlife Service. 2003a. Tennessee lake sturgeon restoration program 2002 monitoring and fisherman reports. United States Fish and Wildlife Service, Atlanta, GA. 1 p.

This document was not available for annotating.

United States Fish and Wildlife Service. 2003b. Illegal caviar traders paddled. TRAFFIC Report 2: 4.

This short article discussed the indictment of 13 people from Eastern Europe for illegally trading paddlefish and sturgeon caviar. Another 8 people were arrested and charged with illegally harvesting white sturgeon (*Acipenser transmontanus*).

United States Fish and Wildlife Service. 2004. Tennessee lake sturgeon restoration program 2003 monitoring and fisherman reports. United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

United States Fish and Wildlife Service. 2005a. Final environmental assessment for fish passage in the Red River of the north basin, Minnesota. Prepared for United States Fish and Wildlife Service, Region 3, Fort Snelling, MN. 49 p. + apps.

This report examined the re-establishment of fish passage at 13 barriers on the Red River and its Minnesota tributaries. Dam removal, modification of culverts and rock slope fishways were considered in detail. Lake sturgeon were mentioned on page 14 as having once been abundant in the Red River Basin. Reasons given

for their decline included: over exploitation, water quality degradation, habitat degradation, and construction of barriers. Current management strategies were briefly discussed.

United States Fish and Wildlife Service. 2005b. Great Lakes lake sturgeon rehabilitation. 3 p. United States Fish and Wildlife Service, Ashland Fishery Resources Office, Ashland, WI. Available from <http://www.fws.gov/midwest/sturgeon/document/s/CoopConservation-LAS1.pdf> [accessed 10 April].

This document summarized lake sturgeon rehabilitation efforts in the Great Lakes. The rehabilitation goal was "To protect, enhance and rehabilitate lake sturgeon populations and their habitat throughout the Great Lakes, which contribute to a stable and healthy ecosystem and provide for responsible use of sturgeon resources." Remnant spawning populations had been found in 11 of 22 historic spawning tributaries in Lake Superior, 8 of 27 in Lake Michigan, 3 of 29 in Lake Huron, and 3 of 8 in Lake Ontario. Impediments to lake sturgeon rehabilitation included dams, water quality, disease, overharvest, and contaminants. Organizations involved in the rehabilitation were listed.

United States Fish and Wildlife Service. 2005c. Management plan for restoration of the upper Tennessee River lake sturgeon population (draft). United States Fish and Wildlife Service, Atlanta, GA. 12 p.

This document was not available for annotating.

United States Fish and Wildlife Service. 2005d. Tennessee lake sturgeon restoration program 2004 monitoring and fisherman reports. United States Fish and Wildlife Service. 2 p.

This document was not available for annotating.

United States Fish and Wildlife Service. 2005e. Tennessee lake sturgeon restoration program 2004 stocking overview. United States Fish and Wildlife Service, Atlanta, GA. 2 p.

This document was not available for annotating.

United States Fish and Wildlife Service, Great Lakes Basin Ecosystem Team Lake Sturgeon Committee. Date unknown. Lake sturgeon: giant of the Great Lakes. Shedd Aquarium, Patrice Ceisel. 5 p. [Brochure]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/LakeSturgeon.pdf> [accessed 10 April 2006].

This brochure discussed the history of lake sturgeon in the Great Lakes, factors that contributed to their decline, and current rehabilitation efforts and regulations.

Upper Columbia White Sturgeon Recovery Initiative. 2002. Upper Columbia white sturgeon ...on the brink. Fall and Winter 2002 Newsletter [Revelstoke, BC] 1: 6 p.

The geographic range, threats to survival, and current status of Upper Columbia white sturgeon were presented. The Upper Columbia White Sturgeon Recovery Plan was discussed, with a research update.

Upper Columbia White Sturgeon Recovery Initiative, and BC Hydro. 2001. Future of the white sturgeon. Revelstoke, BC. 6 p. [Brochure].

A description of white sturgeon, a brief examination of the recovery plan, reasons for their decline, current activities of the recovery team, and a list of ways in which the public can become involved in the recovery effort were provided.

Usher, P.J. 1991. Some implications of the *Sparrow* judgement for resource conservation and management. *Alternatives* 18: 20-21.

The *Sparrow* judgement and four tests set out by the Supreme Court were discussed. The judgement indicated that Native fishing rights include a claim to a share of the harvest as well as an interest in the conservation and management of fisheries.

Usher, P.J., and Tough, F.J. 1999. Estimating historical sturgeon harvests on the Nelson River, Manitoba, p. 193-216. In D. Newell and R. Ommer (ed.) *Fishing places, fishing people: issues and traditions in Canadian small-scale fisheries*. University of Toronto Press, Toronto, ON.

The Cross Lake Band filed a claim against Manitoba Hydro for the loss of its domestic sturgeon fishery due to hydroelectric developments. This study outlined methods for determining the loss of a subsistence fishery when there are no historical harvest records. The evidence used by the claimants and the government were compared. An extrapolation of testimony provided at the arbitration resulted in an estimated total harvest of 17,100 kg/yr before disruption. A second estimate was based on a recall survey, done by Symbion Consultants in 1990, of pre-disruption sturgeon consumption at Cross Lake. This resulted in a figure of 6.45/kg/capita/yr raw edible weight, or 12,611 kg/yr total. This was considered a conservative estimate as portion size was likely underestimated. A third method was to extrapolate the Cross Lake estimates from other similar locations. This resulted in a consumption rate of 8.35-9.80 kg/capita/yr. Manitoba Hydro alleged that pre-disruption stocks had been depleted by overfishing and would not have sustained estimated consumption rates (depletion hypothesis). The Department of Natural Resources estimated the historical productivity of the harvest area at 0.099 kg/ha/yr. This gave a maximum sustainable yield of 10,596 kg/yr, including both subsistence and commercial fisheries. Problems with the depletion hypothesis were discussed. The data used by Manitoba Hydro did not support this hypothesis. Confusion in commercial catch statistics (pre-1930) was examined. The reasons for the closure of the Nelson River sturgeon fishery from 1931-1936 were also discussed, and commercial catch statistics from 1929-1946 were included.

Ussov, M.M. 1885. *Polypodium hydriforme*. Novaya forma presnovodnykh tselenterat. Tr. Obshch. Estest. Khazan. Univ. 14: 1-24.

This item was not available for annotating.

Ussov, M.M. 1887. Eine neue Form von Susswasser-Coelenteraten. *Morph. Jahrb.* 1886: 137-153.

The species of coelenterate parasite of sterlet eggs reported by Owsjannikoff (1871) and Grimm (1873), was named *Polypodium hydriforme*. Larger fish (50-70 cm) are more often infected than smaller fish (20-25 cm). The youngest stage in the life cycle of *Polypodium* was a hollow cylindrical blind tubular structure,

15-17 mm long and 1.5 - 2 mm thick, bearing primary buds. The development of the stolon after release from the eggs was described up to the tentacled, fully formed, individual polyp. The ectoderm, endoderm, and mesoderm and their components were described. Other anatomical features described included tentacles, oral opening, gastral cavity, and cnidoblasts. A mathematical scheme was developed for the organization of successive generations of *Polypodium*. Polyps fed on microorganisms (Infusoria and rotifers) by preying on them with their tentacles.

van Ogtrop, A., and Salmon, R. Date unknown. Lake Nipigon commercial fishery (1998), p. 1-3. In NWST Tech. Rep. **TR-124**.

The 1998 commercial lake sturgeon harvest in Lake Nipigon was 71 pounds (round weight). This comprised less than 1% of the total harvest and 4% of the lake sturgeon quota (1,700 pounds round weight).

Van Oosten, J. 1956. The lake sturgeon, p. 9-10. In *Our Endangered Wildlife*. National Wildlife Federation, Washington, D.C.

This popular article described the general life history of lake sturgeon, the process of its extirpation, and its status as a depleted species. The future of the sturgeon and hopes for its restoration were described as bleak if earnest research efforts were not initiated to overcome existing problems in culture techniques.

Van Oss, J. 1994. Sturgeon and sturgeon spearers of the Lake Winnebago region, 1920-1990, p. 14. In *The International Conference on Sturgeon Biodiversity and Conservation*. The American Museum of Natural History, July 28-30, 1994. Poster Abstracts. [Poster abstract].

Van West, J.J. 1990. Ojibwa fisheries, commercial fisheries development and fisheries administration, 1873-1915: an examination of conflicting interest and the collapse of the sturgeon fisheries of the Lake of the Woods. *Nat. Stud. Rev.* **6**: 31-65.

The historical Ojibwa [Ojibway, Ojibwe] sturgeon fishery on Lake of the Woods and Rainy River was discussed, and the impacts of Treaty Three on Ojibwa [Ojibway, Ojibwe] fishing rights were examined. A discussion of the non-Native commercial fisheries from 1884 to 1915 was

also included. The article concluded with an examination of Federal fisheries administration and Native fishing rights in Canada.

Vandergoot, C. 2005. Summary of voluntary lake sturgeon reports from the western basin of Lake Erie. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 21 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 10 April 2006].

Various authors. 1944-1992. Collection of unpublished lake sturgeon memos 1944 - 1992, Manitoba Game and Fishery Branch. 37 p.

These memos concerned northern Manitoba's commercial sturgeon fishery. Limited harvest statistics were included for Nelson River, Big Playgreen Lake and Cross Lake.

Vecsei, P. 2005. Gastronome 101: how capitalism killed the sturgeons. *Environ. Biol. Fishes* **73**: 111-116.

The book "Caviar, The Strange History and Uncertain Future of the Worlds Most Coveted Delicacy" was reviewed. It was written by I. Saffron and published in 2002 by Broadway Books.

Vecsei, P., and Peterson, D. 2004. Population dynamics and life history of lake sturgeon in the Muskegon River, Michigan. In *Program and Abstracts, 134th Annual Meeting of the American Fisheries Symposium*. Madison, Wisconsin. Pagination unknown. [Abstract only].

Analysis was performed on migrating sturgeon caught in 2002 and 2003 at the mouth of the Muskegon River to determine sex and reproductive condition. Radio transmitters were also attached to at least seven fish in each of the years to monitor seasonal movements. The run size was determined to be 24 fish in 2002 and 15 fish in 2003. Radio telemetry data revealed one active spawning site but the population appeared to be small and rehabilitation measures were being considered.

Vecsei, P., and Peterson, D. 2005. Lake sturgeon of the Great Lakes: a history of exploitation, decline, and recovery, p. 67-68. *In* 2005 abstracts of oral presentations, Canadian Conference for Fisheries Research and the Society of Canadian Limnologists 2005 meeting, Windsor, Ontario, 6-9 January, 2005. Pagination unknown. [Abstract only]. Available from www.phys.ocean.dal.ca/ccfrr/ [accessed 10 April 2006].

Verdon, R., and Gendron, M. 1991. Creation of artificial spawning grounds downstream of the Riviere-des-Prairies Spillway. Canadian Electrical Association, Hydraulic Power Section, Engineering & Operating Division, Vancouver, BC. 14 p.

Granular material was used to create an artificial spawning ground downstream of the Riviere-des-Prairies Spillway in the summer of 1985. The design criteria were based on field data from walleye and lake sturgeon spawning sites. Walleye spawned in spring at temperatures of 5-13°C, in depths of less than 2 m and water velocities ranging from 0.4-1.25 m/s on a gravel, pebble and boulder substrate. Lake sturgeon spawned at water temperatures of 10-13°C, in depths of less than 2 m, and at water velocities ranging from 0.12-2.14 m/s on a pebble and boulder substrate. A total of 6,000 m³ of gravel, pebbles and boulders were added to the river bed 250 m below the spillway. Walleye, sauger, longnose sucker, white sucker, and lake sturgeon used the new spawning grounds. Fifty-nine lake sturgeon were caught over 5 years of study. Number and catch per unit effort of eggs collected were provided in Table 1. Peak spawning was occurred at water temperatures of 12-15°C. Sturgeon larvae also used the new habitat.

Vladykov, V.D. 1933. Biological and oceanographic conditions in Hudson Bay 9: fishes from the Hudson Bay region (except Coregonidae). *Contrib. Can. Biol. Fish. New Series VIII* : 13-61.

Reports of lake sturgeon from James Bay and Hudson Bay were discussed on page 42, followed by a brief description of habitat, distribution, and economic value.

Vladykov, V.D. 1955. Poissons du Québec - Les esturgeons. Département des Pêcheries, Province de Québec. Album 5. 11 p.

This was a general review of sturgeon in Québec where the French speaking fishermen refer to it by several names: Esturgeon jaune or Camus for adults, Escargot, Maille or Charbonnier for the young. Young sturgeon had large black spots on their snouts, back and sides. The black spots disappeared in the adults which became a uniform brownish colour. These lake sturgeon were normally freshwater but during the rainy season they descended to brackish water. Published records for the largest male was 220 pounds and 275 pounds for the largest female with catches ranging in size from 50 to 125 pounds. There was a general review of the biology of sturgeon covering the lack of external features for sexing male and females, spawning (between May and July), food habits, and growth. Young sturgeon grew from 2.3 to 4.5 inches from August to November. After the rapid early growth it took about five years for a sturgeon to double its weight. Commercial fishing in Québec occurred in the James Bay drainage, especially the Ottawa River and its tributaries in Abitibi, Temiscamingue, and Pontiac counties. Other areas included the St. Lawrence River from Lake Ontario to the brackish St. Roch des Aulnaies. Intensive fishing occurred near Lake of Two Mountains, lakes St. Francis, St. Louis, and St. Peter and the St. Lawrence east to Montmagny. The rivers most frequented by sturgeon on the south shore of the St. Lawrence were Bichelieu, St. Francis, and Nicolet, and on the north shore, the Batiscan, and St. Anne. Sturgeon were not found in Lake St. John, the Saguenay or the tributaries of the Gulf of St. Lawrence. Lake sturgeon were captured in the estuary of the St. Lawrence from Lotbiniere to Montmagny. Fish were caught with gill nets, baited lines and in weirs or fascines. The average yield was about 200,000 pounds.

Vladykov, V.D. 1956. Fish tags and tagging in Québec waters. *Trans. Am. Fish. Soc.* **86**: 345-349.

This paper discussed tag returns from eight commercial fishes tagged with different types of tags during 1945-1956. Experiments were carried out with cattle ear tags, ring-shaped strap tags, and split ring and plate tags. Of 1,005 lake sturgeon that were strap tagged between 1945 and 1954, 68 tags were recovered (6.7% return). The maximum time between tagging and recovery was 10 years and the maximum distance between tagging and recovery stations

was 130 miles. This was in contrast to a maximum of 892 miles traveled by the Atlantic sturgeon. Most of the tagging studies were conducted in the St. Lawrence River.

Vladykov, V.D. 1985. Record of 61 parasitic lampreys (*Ichthyomyzon unicuspis*) on a single sturgeon (*Acipenser fulvescens*) netted in the St. Lawrence River (Québec). *Nat. Can. (Qué.)* **112**: 435-436.

A lake sturgeon from Saint-Pierre-les-Becquets (Québec) weighing 16 kg was parasitized by 61 silver lampreys (*Ichthyomyzon unicuspis*). The average length of the lampreys was 104 mm (range: 89-130 mm). The total weight of the 61 individuals was 120 g.

Vladykov, V.D., and Beaulieu, G. 1946. Études sur l'esturgeon (*Acipenser*) de la Province de Québec. I - Distinction entre deux espèces d'esturgeon par le nombre de boucliers osseux et de branchiospines. *Nat. Can. (Qué.)* **73**: 143-204.

The two species of sturgeon (*Acipenser oxyrinchus* and *A. fulvescens*) in Québec were described as part of a two year study to evaluate the commercial fishery in the St. Lawrence. Over 2,500 individuals were studied. The mean length of *A. fulvescens* was 303 cm and of *A. oxyrinchus*, 354 cm. Major differences between the two species were based on the bony scutes (plates) and the number of branchiospines (gill rakers). The arrangement of the bony scutes between the anus and the anal fin for *A. fulvescens* were no more than three rows, with two only in the first or second row. The arrangement of scutes post-anally in terms in the ventral view differed substantially between the two species. Similarly, the scute pattern (post dorsal fin) showed very different patterns in scute arrangement between the two species. The gill raker counts for the first gill arch of *A. oxyrinchus* were a minimum of 16, a maximum of 27 and a mean of 21.6. The gill raker counts for the first gill arch of *A. fulvescens* were a minimum of 27 a maximum of 39 and a mean of 33.1. The text was well supported by numerous photographs and drawings.

Vladykov, V.D., and Beaulieu, G. 1951. Études sur l'esturgeon (*Acipenser*) de la Province de Québec. II - Variation du nombre de branchiospines sur le premier arc branchial. *Nat. Can. (Qué.)* **78**: 129-154.

The number of gill rakers on the first branchial arch were used to differentiate *Acipenser fulvescens* from *A. oxyrinchus*. Less than 4% of the specimens of *A. oxyrinchus* could be confused with *A. fulvescens* in terms of total gill rakers. Less than 2 % of *A. fulvescens* had the same number of gill rakers as *A. oxyrinchus*.

Vladykov, V.D., and Greeley, J.R. 1963. Order Acipenseroidae. *Contrib. Dép. Pêch., Qué.* **53**: 24-60. [Reprinted from: *Fishes of the Western North Atlantic*, Memoir Sears Found. Mar. Res.].

This account, based on preserved specimens, described the five types of sturgeon (species and subspecies) found along the east coast of North America. It also discussed their life histories and geographical distributions, and listed synonyms and references. A general account on world sturgeon species preceded a more detailed consideration of the eastern North American species. A key to all North American sturgeon was provided. *Acipenser fulvescens* was described from 800 specimens caught mainly along various sections of the St. Lawrence River. Its viscera differed from that of the Atlantic sturgeon in being black. Among the east coast species studied, the lake sturgeon was second in size to the Atlantic sturgeon. In 29 stomach samples analyzed for food contents, mayfly (*Hexagenia*) larvae had the highest prevalence (76%), followed by amphipods (73%), gastropods (48%), bivalves (35%) and fish (24%). The lake sturgeon was considered to be of greatest commercial value for its smoked flesh. Lake sturgeon had been occasionally taken from brackish water but there was no evidence for a marine resident population. It was considered an exclusively freshwater species.

Volkman, E.T., Pangle, K.L., Rajchel, D.A., and Sutton, T.M. 2004. Hatchery performance attributes of juvenile lake sturgeon fed two natural food types. *N. Am. J. Aquac.* **66**: 105-112.

This study examined differences in absolute and specific growth in length and weight, food conversion efficiency, and proximate-body composition of juvenile lake sturgeon fed different combinations of brine shrimp and bloodworms over a 10-week period in the lab. Five diet combinations were tested, namely, 100% bloodworms, 75% bloodworms and 25% brine shrimp, 50% blood worms and 50% brine shrimp, 25% bloodworms and 75% brine shrimp,

and 100% brine shrimp. Criteria evaluated included mean specific growth rate (SGR), daily absolute growth rate (AGR), percent weight gain (%WT), and food conversion efficiency (FCE). Initially, fork length ranged from 93-98 mm with a mean of 96 mm, and there were no significant differences among treatment groups. By the end of the study, mean fork length was significantly different among groups. The mean fork length of sturgeon was 183 mm in the 100% bloodworm group, and 118 mm, and in the 100% brine shrimp group. The mean fork lengths of intermediate groups increased with dietary bloodworm content. Wet-weight initially ranged from 5.72-6.33 g, with a mean of 6.06 g, and there were no significant differences among groups. At the end of the study, mean wet weight differed significantly among groups. The mean wet weight was 37.5 g for the group fed 100% bloodworms, and 9.5 g for the group fed 100% brine shrimp. The mean wet weight of the remaining groups increased with dietary bloodworm content. The SGRs and AGRs in both length and weight showed similar results. The %WT was positively correlated to the proportion of bloodworms in the diet. Mean final whole-body protein content was significantly greater for the group fed 100% bloodworms. The authors recommend that age-0 lake sturgeon reared in hatcheries be fed natural diets containing a high proportion of bloodworms.

Vondett, H.J. 1957. A questionnaire census of sturgeon spearing, January - February, 1956, on Black, Burt and Mullett Lakes, Cheboygan County. Mich. Dept. Nat. Res. Inst. Fish. Res. Rep. 1529: 12 p.

In 1956, a questionnaire census was conducted for the first time on the winter lake sturgeon spear fisheries at Black, Burt and Mullett lakes to determine the number and size of sturgeon harvested and fishing pressure. There were 156 shanties on the sturgeon fishing grounds (of a total of 473 shanties); of 106 questionnaires sent out 74 were returned. The number of sturgeon spearkers for the season was estimated at 103, 64% of whom were covered by this census. Based on survey responses, fishermen spent 6,582 hours of fishing effort (1,316 fishermen days @ 5 h spent spearing per day) to harvest 52 fish (127 hrs/fish). Black Lake had the heaviest fishing pressure (3,519 hours) and yielded the most fish (42). The average length was 54.5 inches, and 31% of the fish caught were over the minimum legal limit of 42 inches.

Of 51 fishermen, 53% considered the fishing to be the same as previous years.

Vondett, H.J., and Williams, J.E. 1961. The sturgeon fishery of Black, Burt, and Mullett lakes, Cheboygan County, 1957-1958. Mich. Dept. Nat. Res. Inst. Fish. Res. Rep. 1616: 29 p.

A questionnaire census of the winter sturgeon fishery on Black, Burt and Mullett lakes was conducted in 1957-1958. The census results obtained for the three years (see above) were compared, and the age and growth data was summarized. The total number of sturgeon spearing shanties increased marginally on Black Lake and decreased on the two other lakes. The total number of spearkers declined over the two seasons (129 to 108), as did the number of hours (4,751 to 3,720). The number of fish speared increased from 8 to 14 and the hours/fish decreased from 594 to 266. Burt Lake produced only two fish in 1957 and none in 1958. Black Lake was the most productive, with the highest number of fish and the least number of fishing hours per fish. Data from the 1957-1958 census was compared to the 1956 data and the trends appeared similar, with the 1956 season and Black Lake being the most productive. Data on length-weight and age parameters indicated that a large proportion of the sturgeon speared in Black Lake were removed before they reached 60 inches in length, and the limited data suggested that Michigan lake sturgeon attained legal size (42 inches) when they weighed 12-15 pounds and were 15 years of age. The populations of these three lakes had reportedly been isolated from the Great Lakes population since 1868 by a dam on the Cheboygan River. The Alverno Dam, on the lower Black River, had separated the Black Lake population from the other two since 1903. Two other dams built since then, Tower and Kleber, restricted spawning migrations and sturgeon presently spawn at the foot of the dams. Imposing season limits on sturgeon and spacing the spearing season every 4-5 years was suggested as a means of conserving this species. Tagging studies were recommended for the Upper Black River to investigate migration and spawning habits.

Waddell, J.M. 1970. The biggest fish ever caught in Manitoba waters, p. 69-71. In *Dominion City: facts, fiction and hyperbole*. Derksen Printers, Steinbach, MB.

This short book chapter provided an account of the largest fish, a lake sturgeon, caught in Manitoba. The sturgeon was caught by Sandy Waddell in October of 1903 in the Roseau River. It was reportedly over 15 feet long and weighed over 400 pounds.

Wagner, M.W. 1986. Domestic hunting and fishing by Manitoba Indians: magnitude, composition and implications for management. *Can. J. Native Stud.* 6: 333-349. Available from <http://www.brandonu.ca/Library/CJNS/6.2/wagner.pdf> [accessed 10 April 2006].

The Indian reserve communities of Berens River, Brokenhead, Cross Lake, Hollow Water, Pine Creek, Pukatawagan, Rolling River, Sioux Valley, Split Lake, and The Pas were surveyed to determine the magnitude and composition of domestic hunting and fishing harvests. Fifty-two of the 339 households surveyed had eaten lake sturgeon in the previous year. Joint management was recommended for fish and wildlife populations.

Waldman, J.R. 1995. Sturgeons and paddlefishes: a convergence of biology, politics, and greed. *Fisheries* 20: 20-21 & 49.

Concerns stemming from the International Conference on Sturgeon Biodiversity and Conservation were highlighted. For the majority of the sturgeon and paddlefish populations, the greatest problems were rooted in anthropogenic activities that caused habitat destruction, overfishing, and pollution. Unfortunately sturgeon had a strong geographical connection with human population centers because these fish spent much or all of their life in rivers and estuaries, which were usually heavily occupied by humans. The status of different species of sturgeon and paddlefish was discussed in terms of their geographical location.

Walker, C.R. 1952. The sturgeon. *MO Conserv.* 13: 16.

The sturgeon of Missouri's freshwaters were described. Three acipenserids were present, of which the lake sturgeon was the largest. Individuals 200 pounds in weight were reported in 1911. Commercial sturgeon harvest (mostly shovelnose) ranged from 6,000-13,000 pounds a year over seven years prior to 1952. The 1946 harvest was only 6% of the 1899 catch. The alteration of habitat by impounding waters for

navigation pools was thought to have contributed to the near elimination of the sturgeon. The failure of artificial propagation of sturgeon was attributed to the difficulty in obtaining ripe and running females.

Wallace, R.G. 1991. Species recovery plan for lake sturgeon in the lower Saskatchewan River (Cumberland Lake Area). *Saskatchewan Parks and Renewable Resources Fish. Tech. Rep.* 91-3: viii + 51 p.

The status of the lake sturgeon population in the Cumberland Lake area was discussed. The report outlined the historical causes for decline, including the loss of half of the mature sturgeon population in 1960, during the construction of the Squaw Rapids hydro-electric dam; elimination of large spawning grounds through re-routing of waterways; water-level fluctuations by hydro dams during spawning; and continued commercial exploitation at the same level, despite the above changes to the population. A comparison between commercial catches of 1958 and 1975-1980 showed a disappearance of sturgeon above 40 years of age. The commercial fishery was monitored in 1990 and showed that introduction of young individuals into the population was occurring at only 8-15% of the former level. Growth of Saskatchewan River sturgeon (as expressed by fork-length over age) compared favorably with other populations (Winnebago, Upriver, St. Lawrence, Menominee, Nipigon, Nelson etc., see Fig. 5 on p.10). The recovery plan included public awareness, habitat enhancement and protection, reduction of fishing quotas and protection of spawners, inter-provincial cooperation, and applying for funding.

Wallace, R.G. 1999a. Lake sturgeon in the lower Saskatchewan River: spawning sites, general habitat, and tagging, 1994-1997. *Saskatchewan Environment and Resource Management Fish Wildl. Tech. Rep.* 99-3: ix + 91 p.

This project addressed the habitat inventory and evaluation and population assessment aspects of a lake sturgeon restoration plan for the Saskatchewan River. Potential spawning sites identified included Big Stone Rapids, the E.B. Campbell tailrace, and the Torch River outlet. Sturgeon fry were caught in the Torch (May-July, 1994 and June, 1995), Bigstone (June, 1994 and June-July, 1995), Mossy (June 1994

and 1995), and Centre Angling rivers (July, 1994). Spawning temperatures, which were considered to be 10-17.5°C, were reached at least one week earlier in the Torch River and Bigstone Rapids than at the E.B. Campbell Dam. Mercury content was determined for 37 sturgeon in 1994. The average was 0.18 mg/kg with a range of 0.04-0.31 mg/kg. These levels were within safe limits for human consumption; restrictions on commercial harvest and sale occur at 0.5-1.0 mg/kg. General habitat conditions in the Saskatchewan River were discussed. Twenty sturgeon were tagged in 1994, 44 in 1995, and 62 in 1996 and 1997. Recaptures were discussed. Habitat was also assessed at Namew Lake and the Sturgeon-weir River at Sturgeon Landing, where there had been reports of recent sightings. Proposals for spawning habitat restoration and/or mitigation were presented in Appendix F.

Wallace, R.G. 1999b. Traditional knowledge and new techniques for an old species: lake sturgeon and spawning habitat models, p. 54-59. *In* Canadian Society of Environmental Biologists. Fish and Wildlife Research and Management: Applying Emerging Technologies. Proceedings of the 37th Annual Meeting, Edmonton, Alberta, September 28-30, 1997.

Traditional knowledge was used to determine lake sturgeon spawning sites and other habitats in the Cumberland Lake area of Saskatchewan. The sites identified were assessed by sampling the sturgeon, determining general habitat conditions, monitoring movements via radiotelemetry and monitoring the commercial fishery. A hydraulic model and habitat suitability curves were then developed. The methods by which these were completed were outlined.

Wallace, R.G., and Leroux, D.R. 1999. Lake sturgeon in the lower Saskatchewan River: radio-tracking and index fishing, 1994 to 1997. Saskatchewan Environment and Resource Management Fish Wildl. Tech. Rep. 99-4: viii + 83 p.

Lake sturgeon were radio-tagged in Saskatchewan (n=15 fish) and Manitoba (n=10) reaches of the lower Saskatchewan River to follow their seasonal movements. Mature lake sturgeon tagged at the Torch River, Saskatchewan before spawning usually moved upstream toward the E.B. Campbell Dam or into the river. Those tagged at other spawning sites,

such as Bigstone Rapids and Tearing River, moved downstream. Sturgeon tagged at The Pas, Manitoba moved either up- or downstream. After initial movements, most sturgeon remained in local areas for long periods. Index fishing was continued in Saskatchewan and Manitoba. Ten crews were contracted in Saskatchewan and 3 in Manitoba. A total of 246 sturgeon were caught and released in 1996 and 1997. An average of 2.5 to 3.9 market-size sturgeon/crew/week were caught in Saskatchewan. Catch rates from 1983 to 1997 indicated a steady or declining abundance of sturgeon. Nine restoration recommendations were included.

Walton, D.G. 1976. Sturgeon fishery, Cumberland House area, 1975. Department of Northern Saskatchewan MS. Rep. 16 p.

This report outlined the history of the fishery and discussed management aspects such as annual limit, minimum size restrictions, and the use of hooks and nets. The annual quota at the time (6,000 lbs) was considered acceptable but a more in-depth study on population size was urged. Males matured at 16 years of age (39 inches) and females at 20-23 years (42-45 inches). A minimum harvestable size of at least 42 inches (fork length) was recommended, to replace the 10 lb minimum dressed weight. In view of the difficulty in comparing whole sturgeon (delivered when caught by hook) with dressed sturgeon (net fishery), the use standard length was considered more practical. The use of hooks should be discontinued or subject to conditions so as to avoid indiscriminate hooking of undersized sturgeon.

Wang, Y.L., Binkowski, F.P., and Doroshov, S.I. 1985. Effect of temperature on early development of white and lake sturgeon, *Acipenser transmontanus* and *A. fulvescens*, p. 43-50. *In* Binkowski, F. P. and S. I. Doroshov (ed.) North American Sturgeons: biology and aquaculture potential. Dr. W. Junk Publishers, Dordrecht.

The effects of temperature on the timing of early development and survival of white and lake sturgeon were investigated. The different stages of development, pre-hatch (cleavage, gastrulation, neurulation, organogenesis), and post-hatch (yolk-sac stage and yolk depleted) were described with a plate of figures for each species. Development was accelerated by 100% as early as gastrulation between 10 and 20°C.

More advanced stages were accelerated even further in lake sturgeon but the overall development of lake sturgeon was slower than in white sturgeon. Lake sturgeon eggs hatched in 380-430 hours at 10°C and 90-105 hours at 20°C and the yolk-depletion stage was reached 1,316 hours post fertilization at 10°C. All embryonic mortalities occurred between early gastrula and late neurula. Temperatures of 20-22°C during cleavage and 18-20°C during organogenesis lowered embryonic survival.

Ward, H.B. 1917. On the structure and classification of North American parasitic worms. *J. Parasitol.* **4**: 1-13.

Ward considered the forms described by Linton (*Distomum auriculatum*) as being different from those of Lander (*Distomum petalosum* Lander in Loos, 1902). *Acrolichanus* was erected as a new generic name and differentiated from *Crepidostomum*.

Ward, H.B., and Magath, T.B. 1917. Notes on some nematodes from freshwater fishes. *J. Parasitol.* **3**: 57-64.

Cucullanus clittarius was erected and described as a new species from the intestine of lake sturgeon in Lake St. Clair. Morphological characters included: males = 10-11 x 0.38 mm; females = 12-1 x 0.5 mm; head bent dorsal 60-90 degrees; clitellar like swelling 1.5 mm from anterior tip; three papillae on each oral margin; oral valves = 0.45 x 0.32 mm in males, and 0.33 x 0.24 mm in females; esophagus = 1.45 x 0.12-0.22 mm in males, and 1.6 x 0.13-0.32 mm in females; caudal region of males bent in a single turn; ventral sucker 0.51 mm anterior to anus, diameter = 0.1 mm; male spicules = 1.62 x 0.035 mm and "gouge" shaped, accessory piece = 0.06 x 0.015 mm; 2 preanal and 4 postanal papillae; uterus and ovary double; ova = 63 x 46 µm; distance of vulva from the anterior end = 5/9 -2/3 of total body length.

Warren, M.L., Jr., Burr, B.M., and Kuhajda, B.R. 1986. Mississippi River sturgeons: new Kentucky records and comments on status. *Trans. KY Acad. Sci.* **47**: 52-53.

This was the first confirmed report of lake sturgeon in the Mississippi River of Kentucky. Records of lake sturgeon from this river in the 20th century had been anecdotal and the authors considered the population in the state as

endangered. The occurrence of two other acipenserids in the state (pallid and shovelnose) was also discussed.

Watters, D. 1993a. Lake sturgeon, *Acipenser fulvescens* Rafinesque, in the North Saskatchewan River, Alberta. Fish and Wildlife Service, Department of Environmental Protection, Edmonton, Alberta. vii + 40 p.

A baseline study was conducted in 1991 and 1992 on lake sturgeon captured from the North Saskatchewan River. These fish represented many year-classes, with the majority being from 1984 to 1986. Total lengths ranged from 600 mm to 1,707 mm. Tag returns showed a displacement of 80 km, and allowed a population estimate of 1,923 sturgeon. However, the 95% confidence intervals on this estimate were wide because of the small sample size.

Watters, D.V. 1993b. Lake sturgeon, *Acipenser fulvescens* Rafinesque, in the North Saskatchewan River, Alberta: a summary of activities during 1993. Alberta Environmental Protection, Fish and Wildlife Service Manuscript Report, Edmonton, AB. vii + 37 p.

Results from the third year of an ongoing study to collect baseline data on lake sturgeon in the North Saskatchewan River from volunteer anglers were presented. A 420 km reach of the river (100 river km upstream of Edmonton and 320 km downstream of Edmonton) was sampled. Anglers reported catching 99 lake sturgeon, and 2 were caught in setlines between 15 May and 11 October, 1993. Angling catch per unit effort was 0.061 lake sturgeon per rod-hour. Setline catch per unit effort was 0.003 sturgeon per setline-hour. Most capture locations had substrates of silt/rock, deep water (1.75-6.1 m), and a low water velocity within a back eddy. Total lengths ranged from 740-1816 mm. Weights ranged from 2.39-20.5 kg. Sturgeon from the 1984, 1985, and 1986 year classes dominated the catch. Twenty-three tagged sturgeon were recaptured in 1993, with an average distance between captures of 27 km. A population estimate of 724 sturgeon for 1992 was arrived at using Chapman's modification of the Peterson estimate on 1993 recapture data. Radio-telemetry was used to monitor the movements of 5 lake sturgeon in August, 1993. Four of the marked sturgeon displayed localized movement patterns and one migrated

downstream approximately 22 km within 28 days of being marked. Results were compared to those from the previous 2 years of study.

Watters, D. 2005 in prep. Lake sturgeon movement trends and habitat use in the North Saskatchewan River, Alberta. Fisheries Management Branch Technical Report (Preliminary Report). Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB. Pagination unknown.

At writing this document was in preparation and not available for annotating.

Webb, P.W. 1986. Kinematics of lake sturgeon, *Acipenser fulvescens*, at cruising speeds. Can. J. Zool. **64**: 2137-2141.

This study used sturgeon to test the hypothesis that the locomotor kinematic pattern of teleosts was a general one for actinopterygians, and that the differences in patterns with selachians were to maintain appropriate phase differences between median fins to increase efficiency. The 2-minute critical swimming speed of sturgeon was calculated at 38.6 ± 4.2 cm/sec or 2.45 ± 0.23 total body length/sec at 15°C. The equations were f (frequency, Hz) = $1.67 + 0.07 \times U$ (speed, cm/sec); a (amplitude, cm) = $3.2 + 0.020U$ and propulsive wavelength (cm) = $11.0 + 0.039U$. Swimming kinematics were similar to those of teleosts and anuran larvae indicating that fin propulsive movements were conserved in evolution. Drag per unit area was 3.5 times higher than other actinopterygians, owing to the scutes. The thrust generated by a swimming sturgeon was an average of 82% that of the same sized trout.

Wedan, D. 2004. Lake Winnebago sturgeon spearing long-term health sampling. La Crosse FRO Accomplishment Highlights Report. United States Fish and Wildlife Service. Jan./Feb.: 8-9. Available from <http://www.fws.gov/midwest/LaCrosseFisheries/publications/index.html> [accessed 10 April 2006].

The 2004 Lake Winnebago, Wisconsin lake sturgeon spearing season was discussed. Once the "safe-harvest" level of males and females was reached, notice was given that the season would end after the next day of spearing. Due to good water clarity and ice conditions, the 2004 season ended after 2 days. The total spearing

harvest was 1854 sturgeon. The largest fish was 80 inches in length, weighed 189 pounds, and was aged at 53 years. It was largest sturgeon caught in Lake Winnebago since record keeping began 73 years ago.

Wehrly, K.E. 1995. The effect of temperature on the growth of juvenile lake sturgeon, *Acipenser fulvescens*. Michigan Dept. of Nat. Res., Fish. Div., Res. Rep. No. 2004: vi + 17 p.

The effect of temperature on growth of lake sturgeon fed excess food was measured to determine if sturgeon were food limited or had a lifestyle requiring low energy use. Test temperatures were 7, 10.5, 15, 19 and 23°C. Fish were fed an excess ration of chironomid larvae two times per day. Growth based on wet weight and dry weight, and growth rate in terms of energy were calculated. Growth rates increased linearly with temperature from 0.71% body weight (BW) per day at 7°C to 1.52% BW/day at 23°C based on wet weight. Growth based on dry weight increased from 0.21% BW/day at 7°C to 1.02% BW/day at 23°C. Growth based on energy increased from 3.25 kJ/g·day at 7°C to 16.37 kJ/g·day at 23°C. Mortality also increased linearly with temperature from 18% at 7°C to 45% at 23°C. These results were compared to published data on the growth of other fish species.

Wei, A., Chow-Fraser, P., and Albert, D. 2004. Influence of shoreline features on fish distribution in the Laurentian Great Lakes. Can. J. Fish. Aquat. Sci. **61**: 1113-1123.

Lake sturgeon were included in Table 1 as an open-water taxocene in the cool-cold thermal group. Correlation analysis showed that lake sturgeon were also significantly correlated with wetlands. This was not surprising due to the presence of lake sturgeon in Lake St. Clair and connecting channels. The species is likely dependent on deeper areas of wetlands.

Weisser, J. 2000. Sea lamprey management program and lake sturgeon, p. 12-14. In T.E. Brooking (ed.) Update on lake sturgeon in New York state waters, Jan. 2000. Abstracts and meeting summary. Lake sturgeon research meeting, Wyndham Syracuse Hotel, Syracuse, NY, January 27, 2000. [Abstract only]. Available from <http://www.fws.gov/midwest/sturgeon/cornell.html> [accessed 10 April 2006].

Weisser, J. 2003. Lake sturgeon protocol treatments 1998 to 2003. United States Fish and Wildlife Service, Sea Lamprey Control. 2 p.

This document was not available for annotating.

Wells, L., and McLain, A.L. 1973. Lake Michigan. Man's effects on native fish stocks and other biota. Gr. Lakes Fish. Comm. Tech. Rep. 20: 57 p. Available from www.glfc.org/pubs/TechReports/Tr20.pdf [accessed 10 April 2006].

This report opened with a description of Lake Michigan, followed by a discussion of the factors that have changed the native fish populations over time. The lake sturgeon was one of 15 species of fish discussed as case studies. The original population of this species was depleted more drastically and over the shorter period than any of the other fish species. The catch plummeted from 3.8 million pounds in 1879 (the year of first production records) to 96,000 pounds in 1899. The trend continued until 1928, when the harvest was only 2,000 pounds. Lake sturgeon fishing on the lake was banned the following year. While sturgeon fishing in the state was legalized in 1951, annual production had not exceeded 5,000 pounds since that time. This decline was attributed to overfishing and stream degradation, coupled by late maturity ages. Prior to the first harvest record of 1879, fishermen had already depleted stocks in an effort to exterminate sturgeon, which were considered nuisance fish because they damaged nets.

Welsh, A.B. 2004. Factors influencing the effectiveness of local versus national protection of migratory species: a case study of lake sturgeon in the Great Lakes, North America. *Environ. Sci. Pol.* 7: 315-328. Available from <http://genome-lab.ucdavis.edu/People/AmyWelsh/Welsh%202004.pdf> [accessed 10 April 2006].

Management policies for lake sturgeon in each state bordering the Great Lakes were discussed and compared to the Federal *Endangered Species Act*. Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York were considered. Four states listed the lake sturgeon as endangered, two as threatened, one as special concern, and in Wisconsin the lake sturgeon was not listed. Legislation and implementation of policies were

discussed for each state. Tribal jurisdictions, Federal authority and Canadian jurisdictions were also examined. State management had been successful due in part to jurisdictional coordination through the Great Lakes Fishery Commission and voluntary management.

Welsh, A.B., and May, B.P. 2004a. Patterns of population genetic diversity in lake sturgeon of the Great Lakes. *In* Programs and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Thirteen microsatellite loci were used to analyze the genetic structure of spawning adults sampled from 8 spawning locations. These results were combined with 7 additional spawning sites previously examined for a total of 15 spawning locations. Results showed that fish from most spawning locations were genetically distinct. The Bad and White rivers of the Lake Superior watershed were separate from other spawning locations. This information may be used to design a genetics-based management plan to conserve the genetic integrity of different spawning populations.

Welsh, A.B., and May, B.P. 2004b. Standardization of microsatellite loci in lake sturgeon. *In* Program and Abstracts. 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin. Pagination unknown. [Abstract only].

Ten microsatellite markers were designed for lake sturgeon that highlighted polymorphic disomic loci. A total of 13 microsatellite loci were standardized among eight laboratories to create more consistency among those participating in lake sturgeon genetic research. Standardization packages were sent to the eight laboratories with known and unknown samples, based on the size of the sequenced clone. Genotypes were examined for accuracy and the coordinating laboratory worked with the standardizing laboratory to rectify discrepancies. Standardization would allow data from multiple labs to be synthesized, creating a more detailed picture.

Welsh, A., and McClain, J.R. 2004. Development of a management plan for lake sturgeon within the Great Lakes basin based on population genetics structure. Great Lakes Fishery Trust Project Number 2001.75: 20 p.

Available from

<http://www.fws.gov/midwest/sturgeon/document/s/GLFTfinal-LASgeneticMgmt.pdf> [accessed 10 April 2006].

The objectives of this study were to standardize microsatellite markers used in conducting lake sturgeon genetic research, collect genetic samples from adults at spawning sites not targeted by other management agencies, and to analyze these data using the standardized microsatellite markers. In total, 13 microsatellite markers were standardized and 624 tissue samples were taken from 19 locations. The analysis showed that the Bad and White River populations were separate from the others, and that there was significant gene exchange between populations in the Detroit/St. Clair system and the Lower Niagara River.

Welsh, A.B., Blumberg, M., and May, B. 2003. Identification of microsatellite loci in lake sturgeon, *Acipenser fulvescens*, and their variability in green sturgeon, *A. medirostris*. *Mol. Ecol. Notes* 3: 47-55.

A total of 254 primer pairs were developed from libraries of lake sturgeon. From these, 128 microsatellite loci were identified in either *A. fulvescens* or *A. medirostris*. Polymorphic loci were identified in both species for 48 of the primer pairs and 14 of the primer pairs amplified polymorphic loci in *A. medirostris* only. The majority of the identified loci seemed to be tetrasomic (79.1% in *A. fulvescens* and 64.5% in *A. medirostris*), giving estimates of the degree of diploidization in these species.

Welsh, A., Hill, T., DeHaan, P., Scribner, K., and May, B. 2005. Spatial population genetic structure of lake sturgeon throughout the Great Lakes. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. 21 slides. [PowerPoint presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/oralabstracts.htm> [accessed 10 April 2006].

Wentworth, R. 2001. Ecological assessment of the Peterson Dam reach of the Lamoille River. Virginia Department of Fish and Wildlife. 28 p. Available from http://www.vtfishandwildlife.com/library/Reports_and_Documents/Fish_and_Wildlife/Ecological_Assessment_of_the_Peterson_Dam_Reach_of_th

[e_Lamoille_River.pdf](#) [accessed 10 April 2006].

The ecological implications of the removal of the Peterson Dam from the Lamoille River, Vermont were discussed. Lake sturgeon, walleye and salmon were the main species considered. Between 1998 and 2002, 9 lake sturgeon were captured and tagged in the Lamoille River and 15 in the Winooski River. Sturgeon eggs were collected in both rivers as well as in the Missisquoi River, indicating that spawning was still occurring. Spawning habitats were described in detail. Dam removal would increase lake sturgeon spawning habitat and restore riverine habitat for juveniles.

Wesenberg-Lund, C. 1937. Coelenterata, p. 29-59. In *Ferskvandsfaunaen Biologisk Belyst Invertebrata I*. Gyldendalske Boghandel Nordisk Forlag, Copenhagen.

Pages 58-59 of this book on the biology of freshwater invertebrates contained an account of *Polypodium hydriforme*. This coelenterate was considered unusual due to its partially parasitic life cycle. Its relationship with other cnidarians was considered unclear as was its complete life cycle. The morphology of the free living polyp was described.

Wesenberg-Lund, C. 1939. Coelenterata, p. 25-57. In *Biologie der Süsswassertiere, Wirbellose Tiere*. J. Springer Publishing Company, Vienna.

Pages 55-57 of this book on the biology of freshwater invertebrates described the biology of *Polypodium hydriforme* with diagrams. This was the German version of the previous reference and essentially contained the same account.

Whillans, T.H. 1979. Historic transformation of fish communities in three Great Lakes bays. *J. Gt. Lakes Res.* 5: 195-215.

Community transformation was examined from early settlement to 1976 in Toronto and Burlington bays of Lake Ontario, and Inner Long Point Bay of Lake Erie. Records of lake sturgeon in Toronto Bay began in 1800. By the 1840s they were reported to be declining. Lake sturgeon only used Toronto Bay for brief periods in the spring, when they congregated in the estuary of the Don River. Deforestation, milling, and construction of dams likely stressed the sturgeon population. Records of lake sturgeon in

Burlington Bay began in 1855. Transformations in this fish community were first noted between 1859 and 1877. Lake sturgeon were noted as one of the species undergoing decline during this period. Between 1878 and 1892, sturgeon were fished heavily and may also have been impacted by water pollution. Records of lake sturgeon in Inner Long Point Bay began between 1880 and 1885. Between 1892 and 1910, numbers declined in association with increased fishing pressure. Between 1924 and 1937, sturgeon numbers fluctuated. The main cause of lake sturgeon decline in all three bays was commercial exploitation.

Wickstrom, R.D., and Merner, G.L. 1970. Commercial fishing inventory of northern Manitoba lakes. Manitoba Dep. Mines Nat. Res., Fish. Br. MS. Rep. No. 69-12 : 51 p.

Commercial fishery harvests were summarized for lakes and rivers of northern Manitoba. Average annual yields were presented for the five most recent years in which fishing occurred. The coordinates, map number, acreage of the lake, average yield per acre and fishing status were also given. Average annual lake sturgeon commercial harvests were reported from the Bigstone (800 lbs), Fox (4,020 lbs), God's (4,760 lbs), Hayes (2,300 lbs), and Nelson (16,640 lbs) rivers; Hayes and Fox rivers combined (6,280 lbs); and Kautunigan (1,600 lbs), Little Cross (700 lbs), Playgreen (20,335 lbs), and Pukatawagan (1,380 lbs) lakes.

Williams, J.E. 1951. Michigan's largest fish, the lake sturgeon. Mich. Conserv. 20: 15-18 (Also, Michigan Dept. Conserv. Ann Arbor, MI. Conserv. Rep. 1297: 5 p.).

This article provided general information on lake sturgeon, such as its body shape, biology, feeding, and life history statistics (age to maturity, large size). The species became commercially important in Michigan in the 1870s for caviar, isinglass, and its skin. By 1885 there was a harvest of 1.5 million pounds but this declined to "...practically nothing by 1926...". Sturgeon spearing had occurred since 1948, concentrated in the Cheboygan and Indian River chain of lakes (Black, Burt, and Mullet). The record sturgeon from Mullet Lake was 152.5 pounds, 78 inches long with 47 pounds of eggs. Michigan planted 580,000 young sturgeon in the Detroit River in 1893 to 1894--this was the only time the Michigan Conservation Department had

been successful at culturing sturgeon. Spawning occurred at temperatures between 60-70°F and rolling, splashing, and jumping were often observed. Several males were associated with each spawning female and it was thought that females did not spawn each year. Young sturgeon fed on small crustacea and adults fed on larval midges, caddisflies, dragonflies, mayflies, clams, snails, and crayfish. Small fish were eaten and large suckers had been found in sturgeon stomachs. A sturgeon caught in Lake Michigan weighed 375 pounds and was eight feet in length. It was suggested that it took 15-20 years for a sturgeon to reach the legal size of 36 inches. There was a discussion on the wanton destruction of sturgeon including the commercial fisheries and work being done in Michigan. The author concluded that very little was known about the life history of sturgeon in Michigan.

Williams, J.E., and Miller, R.R. 1990. Conservation status of the North American fish fauna in fresh water. J. Fish Biol. 37: 79-85.

Of the eight species of acipenserids, two were listed as endangered, two as vulnerable, and one as indeterminate.

Williams, J.E., and Vondett, H.J. 1962. Michigan's largest fish, the lake sturgeon. Mich. Dept. Conserv. Fish Div. Pamph. 35: 6 p.

The general life history of lake sturgeon was described with reference to Michigan waters. The popular presentation did not reference its sources. Information included a brief history of sturgeon fishing in the state, the spawning behavior, and the questionnaire census of 1956-1958 determining the winter fishing status of lake sturgeon in Burt, Mullet and Black lakes. Some of the comparative census data were repeated from other publications and graphs depicted the length-weight and age-length relationship of lake sturgeon from these lakes.

Williams, J.E., Johnson, J.E., Hendrickson, D.A., Contreras-Balderas, S., Williams, J.D., Navarro-Mendoza, M., McAllister, D.E., and Deacon, J.E. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries 14 : 2-20.

This article listed lake sturgeon as being threatened in a number of provinces in Canada and states in the U.S.

Williamson, D.F. 2003. Caviar and conservation: status, management, and trade of North American sturgeon and paddlefish. TRAFFIC North America. Washington, D.C.: World Wildlife Fund. ix + 240 p. Available from http://www.traffic.org/sturgeon_report.pdf [accessed 10 April 2006].

This report examined: the status of North American paddlefish and sturgeon species; federal, state and regional regulations; current levels of legal trade of sturgeon and paddlefish products; illegal catch and trade activities; and developments in aquaculture programs. The historic range and current distribution, ecology and habitat, historic catch, conservation status and challenges/threats were discussed for lake sturgeon. Canadian regulations were examined for Alberta, Saskatchewan, Manitoba, Ontario and Québec. Regulations were also discussed for the following US states: Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, South Dakota, Tennessee, Vermont, and Wisconsin. Caspian Sea sturgeon and paddlefish were in decline, but the caviar trade had not declined at the same rate. Maintaining existing trade levels could have serious implications for the management of North American sturgeon and paddlefish populations if they were used as substitutes. Canada was the only source of commercially caught lake sturgeon in international trade, as commercial harvest for export was not allowed in the US. All exported lake sturgeon were from Ontario and Québec. In the US, Michigan, Minnesota, New York and Ohio allow the domestic trade of lake sturgeon flesh and caviar. Michigan, Minnesota and New York allowed the domestic trade of live lake sturgeon. There was limited information on the illegal harvest and trade of lake sturgeon in Canada. Artificial propagation was also discussed.

Williot, P. (ed.) 1991. *Acipenser*, Actes du Colloque. Premier Colloque International sur l'esturgeon. Centre National Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF). 3-6 October, 1989. Bordeaux, France. 519 p.

The proceedings of the First International symposium on sturgeon held in Bordeaux, France in 1989 were covered. Four of the 43 articles dealt specifically with lake sturgeon.

Three described the population biology of lake sturgeon stocks in the St. Lawrence River and two other water bodies in Québec. Fortin *et al.* (p. 295-314) discussed distinctions between lake sturgeon stocks in the St. Lawrence River and the Lac des deux Montagnes; Gunette and Fortin (p. 327-328) compared the morphology of sturgeon from these water bodies; and Lamourex and Laforce (p. 315-326) presented an analysis of lake sturgeon caught in the St. Lawrence River between 1985 and 1989, with a discussion of their biological characteristics. There was one article on the subsistence lake sturgeon fishery of the village of the Muskrat Dam in Ontario (Michalenko *et al.*, p. 447-458).

Wilson, C.B. 1916. Copepod parasites of freshwater fishes and their economic relations to mussel glochidia. Bull. US Bur. Fish. **34**: 331-374.

Argulus canadensis was reported on the skin and fins of *Acipenser fulvescens* (from the Lake of the Woods, Ontario) for the first time.

Wilson, N.C. 1987. Age determination of lake sturgeon (*Acipenser fulvescens*) by use of the marginal pectoral fin ray, p. 77-83. In C. H. Olver (ed.) Proceedings of a Workshop on the Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. **23**.

Various aspects and problems associated with age determination of sturgeon using sections of the marginal pectoral fin ray were discussed. Cuts to remove this fin ray should be made 3-5 mm from the basal cartilage articulation to minimize blood loss and increase accuracy of readings. The best annular readings were obtained from sections between 250-400 µm thick taken close to the proximal cut end of the ray. The postero-lateral regions of the section provided the clearest readings. Sturgeon under 20 years were easiest to age. Older fish were characterized by clumping of annuli into multiple narrow bands, which could not be accurately counted. Follow-up studies were recommended to determine the effect of fin ray removal on survival of sturgeon aged by this method.

Wilson, R. (ed.) 2004. Pallid sturgeon recovery update - the latest research and management actions for recovery **14**: 25 p. [United States Fish and Wildlife Service, Newsletter].

Pallid sturgeon research and management

activities in the Missouri River were summarized. Diet, habitat use, sampling techniques and a gastric lavage method for examining stomach contents were discussed. Updates from various government offices and hatcheries were included.

Winemiller, K.O., and Rose, K.A. 1992. Patterns of life-history diversification in North American fishes: implications for population regulation. *Can. J. Fish. Aquat. Sci.* **49**: 2196-2218.

Interspecific patterns of fish life history were studied in relation to several theoretical models of life history evolution. Lake sturgeon exhibited an extreme strategy, where age and size at maturation were large, eggs were numerous and small in relation to body size, and spawning was episodic and seasonal.

Winkel, L.A. 2000. Survey of the lake sturgeon (*Acipenser fulvescens*) fishery on the South Saskatchewan River, Alberta. Alberta Species at Risk Report **9**: vi + 21 p. Available from www3.gov.ab.ca/srd/fw/ [accessed 10 April 2006].

A creel survey was conducted on the South Saskatchewan River to determine the utility of existing harvest data on lake sturgeon in Alberta. The creel survey data were compared to data collected from an annual questionnaire sent to all lake sturgeon license holders. Other objectives were to determine the accuracy of extrapolating sturgeon weights from lengths, and to collect information on the nature and extent of sturgeon angling in the South Saskatchewan River. The 79 angling parties surveyed caught a total of 55 lake sturgeon. Length, weight and size distributions were summarized. At least 52% of sturgeon angling occurred without a license; anglers recalled more details when interviewed in person than by a mailed out questionnaire. The accuracy of extrapolating weight from length could not be determined due to the small sample size. The report concluded with a series of recommendations.

Wirgin, I.I., Stabile, J.E., and Waldman, J.R. 1997. Molecular analysis in the conservation of sturgeons and paddlefish. *Environ. Biol. Fishes* **48**: 385-398.

This article summarized sturgeon and paddlefish population biology questions that can be

answered using molecular techniques. A genetic comparison between American Atlantic sturgeon (*Acipenser oxyrinchus*) and European Atlantic sturgeon (*A. sturio*) was also presented. Molecular techniques can be used to identify and discriminate taxa, for analyses of hybridization and introgression, to identify stocks and assess genetic variability, to perform mixed-stock analysis, and to determine gene flow and homing fidelity. Examples were included for each of the above uses.

Wirth, T.L. 1959. Winnebago: the big lake. *Wis. Conserv. Bull.* **24**: 15-19.

Physical parameters such as drainage, rivers and bottom substrate, and biota, particularly fish, were discussed for the purpose of supplying pertinent information to sport-fishermen. Spearing for lake sturgeon was recommended in the winter.

Wisconsin Department of Natural Resources, Bureau of Fisheries Management and Habitat Protection. 2000. Wisconsin's Lake Sturgeon Management Plan. Madison, WI. iii + 12 p.

Lake sturgeon management issues included: (1) the need for biological information on sturgeon population dynamics; (2) habitat loss, modification, or inaccessibility; (3) the need to maintain the genetic diversity and long-term health of rehabilitated sturgeon populations; (4) a need for harvest and exploitation information; (5) the decline of sturgeon populations in Wisconsin over the past 100 years; (6) the need for added protection from illegal harvest and incidental catch by commercial fishers, and for modifications to the current registration system so as to obtain additional information; (7) the requirement for public understanding, support, and involvement; (8) the need for a means of evaluating and ensuring the maintenance of genetic variability and other population characteristics in commercial and private industry; and (9) the lack of adequate statewide management goals and policies. Each management issue was briefly discussed and objectives and recommendations were given. The management plan concluded with an examination of the biology and status of lake sturgeon in Wisconsin and a short discussion on the Native American perspective.

Wisconsin Department of Natural Resources, Bureau of Fisheries Management and Habitat Protection. 2005. 2005 Wisconsin Winnebago pool lakes sturgeon spearing regulations & information. Wisconsin Department of Natural Resources, Madison, WI. 16 p. Available from <http://dnr.wi.gov/org/water/fhp/fish/Winnebago%20Sturgeon%20Spearing%20Pamphlet%202005.pdf> [accessed 11 April 2006].

The 2005 open season was from February 12-27 (or until harvest cap was reached). The harvest caps for 2005 were 500 adult females, 500 juvenile females and 2,000 males. The bag limit was one lake sturgeon (minimum length 36 inches) per license. Regulations concerning tagging, transportation, registration, and fishing equipment were also discussed. A history of the Winnebago sturgeon fishery from pre-1903 to 2004 was presented. In the 2004 spear harvest season 1,854 sturgeon were harvested and 8,924 licenses sold. Twenty fish larger than or equal to 100 lbs were registered, with the largest weighing 188 lbs. The highest one day harvest of lake sturgeon occurred in 2004 when 1,303 sturgeon were caught. The estimated exploitation rates were 4.8% for adult females and 3.3% for males. Harvest data were presented.

Wisconsin Department of Natural Resources, Fisheries Management and Law Enforcement. 1995. Lake Sturgeon update, Lake Winnebago System **December**: 8 p. [Newsletter].

Lake sturgeon research conducted in the Lake Winnebago system, Wisconsin in 1995 was summarized. Research focused on the spearing harvest and spring spawning. Enforcement and management activities are discussed and plans for 1996 are outlined.

Wisconsin Department of Natural Resources, Fisheries Management and Law Enforcement. 1996. Lake Sturgeon update, Lake Winnebago System **December**: 10 p. [Newsletter].

Lake sturgeon research conducted in the Lake Winnebago system, Wisconsin in 1996 was summarized. Spearing harvest and spring spawning were assessed. New harvest regulations were detailed, enforcement and management activities discussed, and plans for 1997 outlined.

Wisconsin Departments of Agriculture, Trade & Consumer Protection and Natural Resources. 2000. p. 1-32, 48-57, & 70-73. *In* Regulatory options for the commercial rearing of lake sturgeon: report to the Legislature, December 2000. Madison, WI.

A public workshop was held in January of 2000 to discuss the commercialization of lake sturgeon in Wisconsin. The following five regulatory options resulted: (1) continue the prohibition of live lake sturgeon, lake sturgeon flesh and caviar; (2) implement the Wisconsin Lake Sturgeon Aquaculture Agreement, which would establish standard criteria for public and private lake sturgeon aquaculture facilities for rehabilitation and stocking only; (3) the creation of a Lake Sturgeon Commercial Management Board to develop and oversee conditions of commercial lake sturgeon operations; (4) the development of a Wisconsin Lake Sturgeon Commercialization Pilot Project to work within the directives of the Wisconsin Lake Sturgeon Management Plan, while allowing a limited number of private commercial operations to research potential commercial markets and assist in stocking efforts; and (5) the full legalization of the harvest, purchase, sale, trade, barter, possession, control and transportation of lake sturgeon by private commercial facilities. The pros and cons of each option were listed. Background information was provided on lake sturgeon biology, current regulations, aquaculture potential, disease and health issues, and public sentiment. A list of contacts was included.

Wm. R. Walker Engineering Inc. 1989. Carmichael Falls hydroelectric project: identification of potential impacts and mitigative measures. Sault Ste. Marie, ON. Pagination unknown.

This document was not available for annotating.

Wood, D. 1995. What's killing the sturgeon? *Beautiful British Columbia* 37: 20-29.

A series of white sturgeon deaths in the Fraser River, British Columbia in 1993 and 1994 were investigated. Thirty-four white sturgeon died for no apparent reason. Investigations to date had resulted in more questions than answers. The decline of white sturgeon in the Fraser River was also discussed.

Wooding, F.H. 1972. The sturgeon family, p. 265-269. In *The book of Canadian fishes* (Revised edition). McGraw-Hill Ryerson Limited, Toronto, ON.

This book chapter provided a general description and discussed the distribution of Canadian sturgeon species.

Woods, L.P. 1956. Problems of conservation in the Great Lakes. *Chicago Nat. Hist. Mus. Bull.* 27: 3-5.

The problems associated with lake sturgeon, whitefish, and lake trout fisheries of the Great lakes were considered. The decline of these three fisheries was regarded not only as a case of overfishing. Selective fishing and the introduction of pound nets in the 1850s resulted in a great number of immature fish being captured. Of the three depleted species, the sturgeon was the first to go. The fishery for sturgeon began around 1870 with initial catches of 10,000- 20,000, reaching a high of 8 million pounds in 1885 and declining rapidly thereafter to a level of commercial insignificance during the 20th century. The general effects of climatic changes, fishing gear, pollution, and the introduction of exotic species were discussed in the context of declining fish populations. The necessity of an overall survey and the need to support various institutes and commissions set up to monitor Great Lakes productivity were discussed.

Xcel Energy. 2001. Lower Chippewa River settlement agreement. Xcel Energy, Minneapolis, MN. 21 p.

This document was not available for annotating.

Yamada, K., and Hoshino, M. 1972. Effects of added electrolytes upon the ruthenium red reactions of model polyanions on filter paper and in tissue. *Acta Histochem. Cytochem.* 5: 18-25.

Chondroitin sulfate A was recovered from the notochord of lake (rock) sturgeon and used as a reference standard for acid mucopolysaccharides. Tissue was recovered, minced, fixed with Carnoy's, dehydrated with ethanol, cleared in benzene, embedded in paraffin, and cut into 8 µm sections. For sulfation, the sections were immersed for 10 minutes at 4°C in 40% (V/V) sulfuric acid in glacial acid. Ruthenium red was the dye being

tested for use in light microscopy. Results indicated that the three anionic groups, sulfates, phosphates and carboxyls, could be responsible for the ruthenium red reactions of polyanions.

Yess, S. 2003. A lake sturgeon success story. La Crosse FRO Accomplishment Highlights Report. United States Fish and Wildlife Service. **Nov./Dec.**: 1. Available from <http://www.fws.gov/midwest/LaCrosseFisheries/publications/index.html> [accessed 11 April 2006].

Lake sturgeon restoration efforts on the White Earth Indian Reservation were discussed. Stocking had been ongoing for 3 years. In October of 2003, 2 young lake sturgeon were caught in White Earth Lake and 4 in Round Lake. Two more years of stocking were called for in the management plan.

Yess, S. 2004. Fishery management reports completed for White Earth Reservation and Tamarac NWR. La Crosse FRO Accomplishment Highlights Report. United States Fish and Wildlife Service. **March**: 1-2. Available from <http://www.fws.gov/midwest/LaCrosseFisheries/publications/index.html> [accessed 11 April 2006].

This short article discussed the completion of a lake sturgeon status report for the White Earth Reservation and a baseline survey conducted on the Ottertail River for the Tamarac NWR.

Young, J.K., and Love, G.F. 1970. The lake sturgeon (*Acipenser fulvescens*) of Lake Nipissing. Ontario Department of Lands and Forests, North Bay District MS. Rep. 24 p.

This document was not available for annotating.

Young, R., and Klar, G. 2003. Integrated management of sea lampreys in the Great Lakes 2003. 61 p.

This document was not available for annotating.

Youson, J.H., and Butler, D.G. 1976. The adrenocortical homolog in the lake sturgeon, *Acipenser fulvescens* Rafinesque. *Am. J. Anat.* 145: 207-224.

The adrenocortical homolog of the lake sturgeon

was examined by histochemistry and electron microscopy to understand its phylogeny among vertebrates. The tissue was located in spherical or oblong yellow corpuscular bodies, approximately 81 in number (in one specimen), along the dorsal band of connective tissue supporting the cardinal veins running between the kidneys. The bodies were concentrated anteriorly and rarely deep within the kidney. Histochemistry revealed that they contained d³-3 β -hydroxysteroid dehydrogenase, common to adrenocortical cells and their homologues in other vertebrates. The corpuscles were made of anastomosing cords of epithelial cells with blood vessels separating them and completely surrounded by homeopietic tissue. The fine structure of the cells was described with the Golgi apparatus as the most conspicuous component along with lipid droplets in large cytoplasmic vacuoles, numerous mitochondria, and a smooth endoplasmic reticulum. The concentration of corpuscles anteriorly indicated a more advanced state in comparison to anadromous Atlantic sturgeon, and followed an evolutionary trend among vertebrates towards the concentration of adrenocortical tissue into larger bodies or in specific areas. Morphological evidence suggested that the corpuscular epithelial cells were actively involved in corticosteroid synthesis.

Yule, D., Cholwek, G., Quinlan, H., and Doolittle, T. 2005. Lower Bad River acoustic mapping project. Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004, Sault Ste. Marie, Michigan. [Poster presentation]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/GLCoordMtg04/posterabstracts.htm> [accessed 11 April 2006].

Zeiber, R., and Sutton, T. 2004. Assessment of remnant lake sturgeon populations in the lower Kalamazoo River, Michigan. United States Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI. 27 p.

This document was not available for annotating.

Zhu, B., Zhou, F., Cao, H., Shao, Z., Zhao, N., May, B., and Chang, J. 2002. Analysis of genetic variation in the Chinese sturgeon, *Acipenser sinensis*: estimating the contribution of artificially produced larvae in a wild population. *J. Appl. Ichthyol.* 18: 301.

Ten sets of the 25 primer sets developed from lake sturgeon and shovelnose sturgeon genomic DNA were tested on mature adults, juveniles, and a single family of Chinese sturgeon from the Yangtze River. Analysis indicated that all four loci appeared to segregate among the offspring in a 1:1 (presence: absence) ratio. Neighbor-joining based on band-sharing in coupling with parentage analysis showed that hatchery individuals may make up 5-10% of the juvenile population of 30,000 to 60,000 larvae.

Zollweg, E.C. 2004. Lake Erie lake sturgeon survey by commercial fishers. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resources Office, Amherst, NY. 4 p. Available from <http://www.fws.gov/midwest/sturgeon/document/s/Lake%20Erie2002-3CommRpt.pdf> [accessed 11 April 2006].

Commercial fishers collected data on sturgeon caught as by-catch on Lake Erie. Total length, weight and girth were measured. A total of 24 lake sturgeon were captured in 2003. Total length ranged from 39.5 to 114 cm, weight from 0.06 to 5 kg, and girth from 11.5 to 39.0 cm. Based on these data the author noted that this was likely a population of juveniles and subadults.

Zollweg, E.C., and Hill, T.D. 2001. Lake sturgeon status survey in Michigan waters of Lake Huron as reported by commercial fishers. United States Fish and Wildlife Service, Alpena Fishery Resources Office, Alpena, MI. 11 p. Available from <http://www.fws.gov/midwest/alpena/documents/rpt-sagbay00.pdf> [accessed 11 April 2006].

The 6th year of lake sturgeon monitoring in Lake Huron was discussed. Lake sturgeon caught as by-catch in the commercial fishery were measured for total length, fork length, and girth. The marginal ray of the left pectoral fin was removed for aging, and the distal portion of the fin ray was collected for genetic analysis. Many of the lake sturgeon were also tagged. Forty lake sturgeon were caught in 2000. Fork length ranged from 40 to 143 cm and age from 4 to 28 years. Biological data were summarized and discussed.

Zollweg, E.C., Dittman, D., and Carlson, D. Date unknown. Lake sturgeon research. United States Fish and Wildlife Service, United States

Geological Survey and New York State Department of Environmental Conservation. 2 p. [Brochure]. Available from <http://www.fws.gov/midwest/sturgeon/document/s/Factsheet-GenesseeNY-LASr2.pdf> [accessed 11 April 2006].

Lake sturgeon research in the Genesee River, New York was discussed. Survey information was to be collected on the 1,900 lake sturgeon that were stocked in the river between 2003 and 2004. Captured sturgeon were to be weighed, measured, tagged, and released. Lake sturgeon habitat use was also to be assessed. A section on why the public should be concerned and how they can help was included.

Zollweg, E.C., Elliott, R.F., Hill, T.D., Quinlan, H.R., Trometer, E., Weisser, J.W., Auer, N.A., Baker, E.A., Carlson, D.M., Holtgren, M., and Thomas, M. 2003. Great Lakes lake sturgeon coordination meeting. Proceedings of the December 11-12, 2002 workshop, Sault Ste. Marie, Michigan. Sponsored by the Great Lakes Fishery Trust. Coordinated by the United States Fish and Wildlife Service. v + 135 p. Available from <http://www.glft.org/grants/funded/133-SturgMtg/GLSturgeonCoordMtg02.pdf> [accessed 11 April 2006].

Basin overviews were discussed for Lake Superior, Lake Michigan, Lake Huron, Lake Ontario, Lake Erie, Lake Ontario, and the St. Lawrence River. There were 54 presentations, each with an abstract. The following topics were addressed: (1) examples of stocking activities and stocking considerations; (2) genetics evaluation of sturgeon populations; (3) juvenile assessment and biology; (4) adult assessment and biology; and (5) impacts on sturgeon survival, habitat, and database development.

Zollweg, E.C., Gunderman, B.J., Elliott, R.F., Kowalski, A., Hill, T.D., and Miller, G. 2003. Lake sturgeon assessment assistance by Great Lakes commercial fishers 2001-2002. United States Fish and Wildlife Service, Lower Great Lakes Fishery Resources Office, Amherst, NY. 26 p. Available from <http://www.fws.gov/midwest/sturgeon/document/s/rpt-GLCommercial01-02.pdf> [accessed 11 April 2006].

Sturgeon caught as by-catch in the commercial fishery were measured for total length, fork length, and girth. The marginal ray of the left

pectoral fin was removed for aging, and the distal portion of the fin ray or a small piece of the caudal fin was collected for genetic analysis. There were 123 reported lake sturgeon captures in Lake Michigan between 1996 and 2002. Roughly 60% of these were from Green Bay. The remaining 40% were mostly from Grand Traverse Bay, Little Traverse Bay, Door County, and east-central Lake Michigan. Total length ranged from 28 to 213 cm, and age from 2 to 61 years. Only two aged sturgeon were older than 30, indicating a young population. There were 51 lake sturgeon catches in Lake Superior since the project began. Total length ranged from 52 to 167.5 cm. Water depth at catch sites ranged from 15 to 150 feet, with the highest rate of capture occurring in 50 feet or less. A total of 359 lake sturgeon were captured in Lake Huron between 1995 and 2002. Total length in 2001 ranged from 53 to 191 cm, and girth from 15 to 83 cm. In 2002, total length ranged from 46 to 200 cm, and girth from 14 to 109 cm. Twenty-five lake sturgeon were captured in Lake Erie in 2001. Total length ranged from 32 to 97 cm, and age from 2 to 7 years. All biological data were summarized and discussed.

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Lake sturgeon caught as by-catch in the commercial fishery were measured for weight, total length, and girth. Twenty-five lake sturgeon were caught in 2001. Total length ranged from 320 to 970 mm, girth from 115 to 390 mm, and weight from 0.06 to 5 kg. Based on the biological data, this population consisted of juveniles and sub-adults.

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